ANTENNAS

BY WILLIAM I. ORR, *W6SAI

"I should worry . . . . . I should care
I should marry a millionaire . . . .
He should die . . . . . I should cry
I should marry another guy . . . . ."

Pendergast leaned back in his chair, tossed the headphones on the operating table and stared out of the window of the shack. The childish chant floated into the room as if on the wings of a light breeze.

"Good grief," said Pendergast. "Look at that! Little girls jumping rope! I haven't seen children jumping rope for 20 years. They're all out sniffing airplane glue and slitting automobile tires now!"

I looked out over Pendergast's shoulder.

*48 Campbell Lane, Menlo Park, CA 94025

CQ is pleased to present the first of a monthly feature written by the well-known author, W6SAI. Bill is the editor of the highly regarded *Radio Handbook* and the author of the *Beam Antenna Handbook, All About Cubical Quad Antennas, The Wire Antenna Handbook*, and others. He has written over 100 technical articles, many of which have appeared in *CQ*. Bill has designed high gain antennas for military and commercial service, and his antenna handbooks have attained world-wide popularity. W6SAI is also an active amateur, holding DXCC (260 countries) and also the operator at 3AØAF and KH6ADR. Bill promises us an interesting column, dealing with various aspects of antennas, California wines and other topics of interest to today's radio amateur. [*California wines??* – Editor.]

His first column touches briefly on a new and interesting antenna design, and the ever-popular triband, trapped beam antenna.

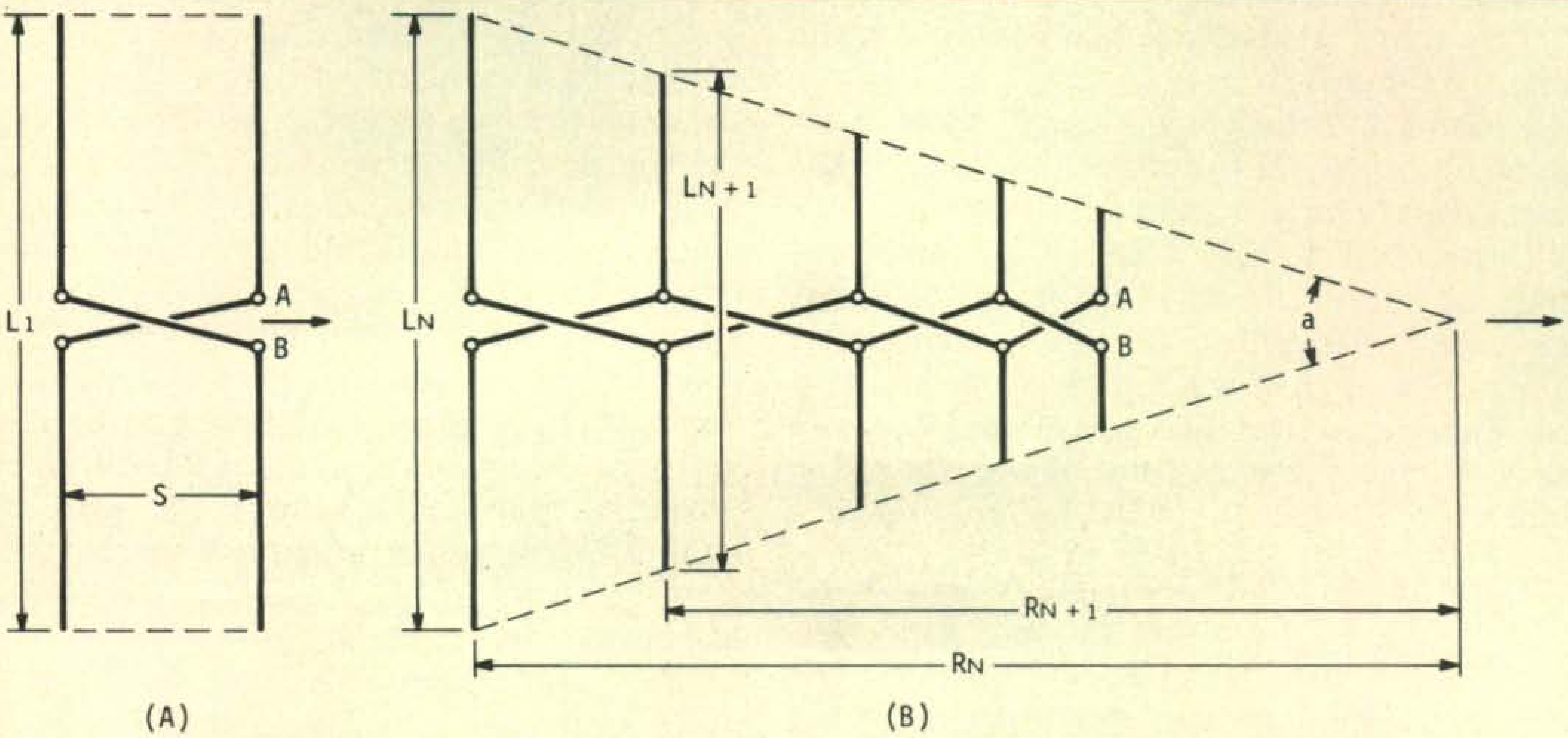


Fig. 1—The ZL-Special antenna (A) may be thought of as one cell of a long-periodic dipole array (B). Operational frequency of the ZL-Special is determined by element length (L_1) and spacing (S), both of which are adjusted for a unidirectional pattern. Phasing line provides proper phase difference between antenna elements. Beam is fed with balanced transmission line at points A-B.

Log-periodic dipole array (B) consists of an array of dipoles with lengths and spacings arranged so that the electrical properties repeat periodically with the logarithm of the frequency. Good frequency independence can be obtained when the variation of the electrical properties over one period (and therefore over all periods) is small. Lengths and spacings are a function of included angle, a. Frequency limits of array are determined by lengths of longest and shortest elements. A single cell of the log-periodic dipole can be thought of as a simple ZL-special beam, operable over a very narrow frequency range.

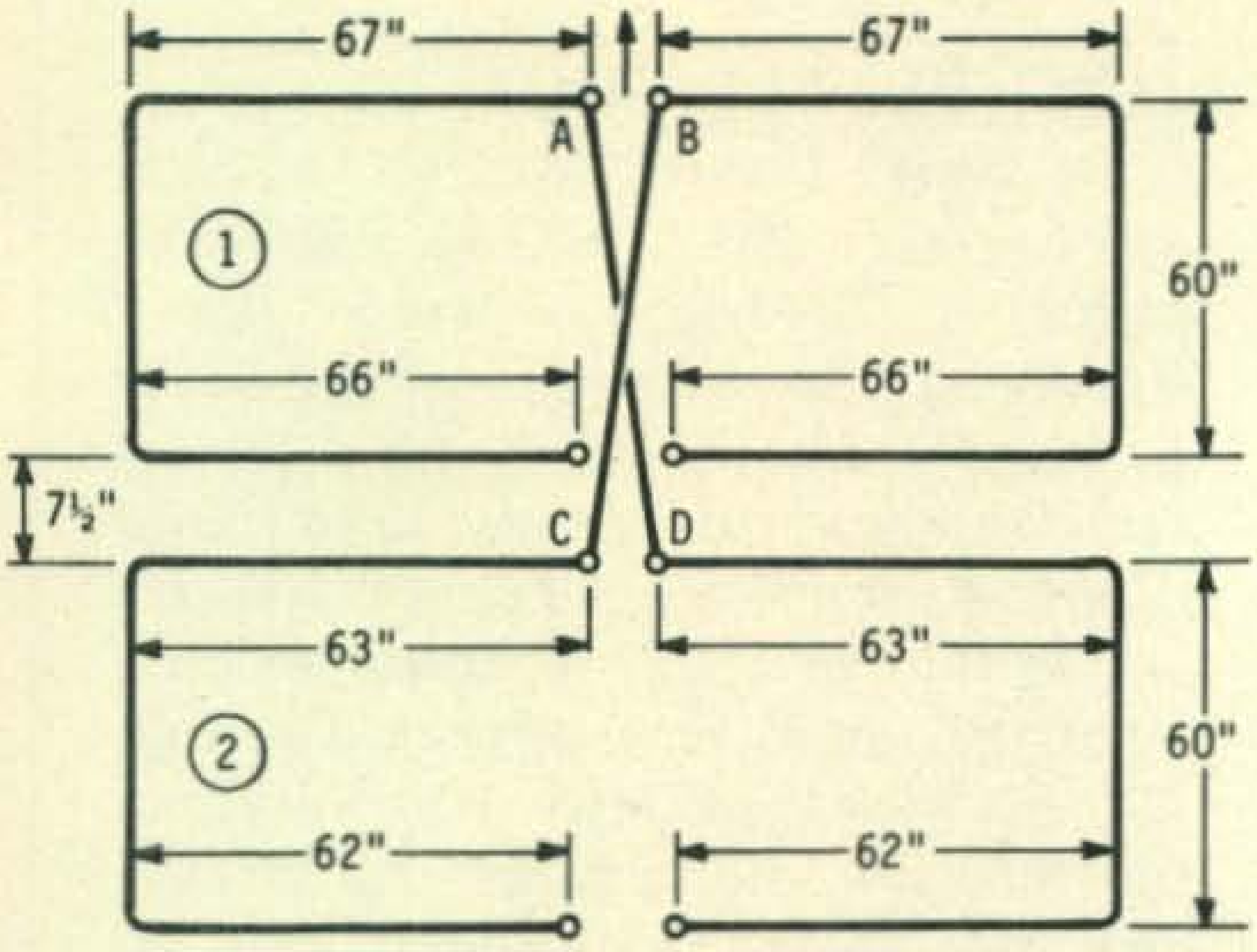


Fig. 2(A)—Drawing of the G3PTN beam for 20 meters. Basically, the antenna is a form of ZL-Special with the ends of the elements folded back in the form of a square. The antenna is fed with a 1:1 balun and a 50 ohm coaxial transmission line at points *A-B*. The phasing line connecting *A-B* to *C-D* is a 86" length of 300 ohm TV-type "ribbon" transmission line, having a 180 degree twist in it. With the phasing line in place, element 1 is adjusted for minimum s.w.r. and element 2 is adjusted for best front-to-back ratio. Elements are constructed in trombone fashion so end sections can slide in and out of center sections

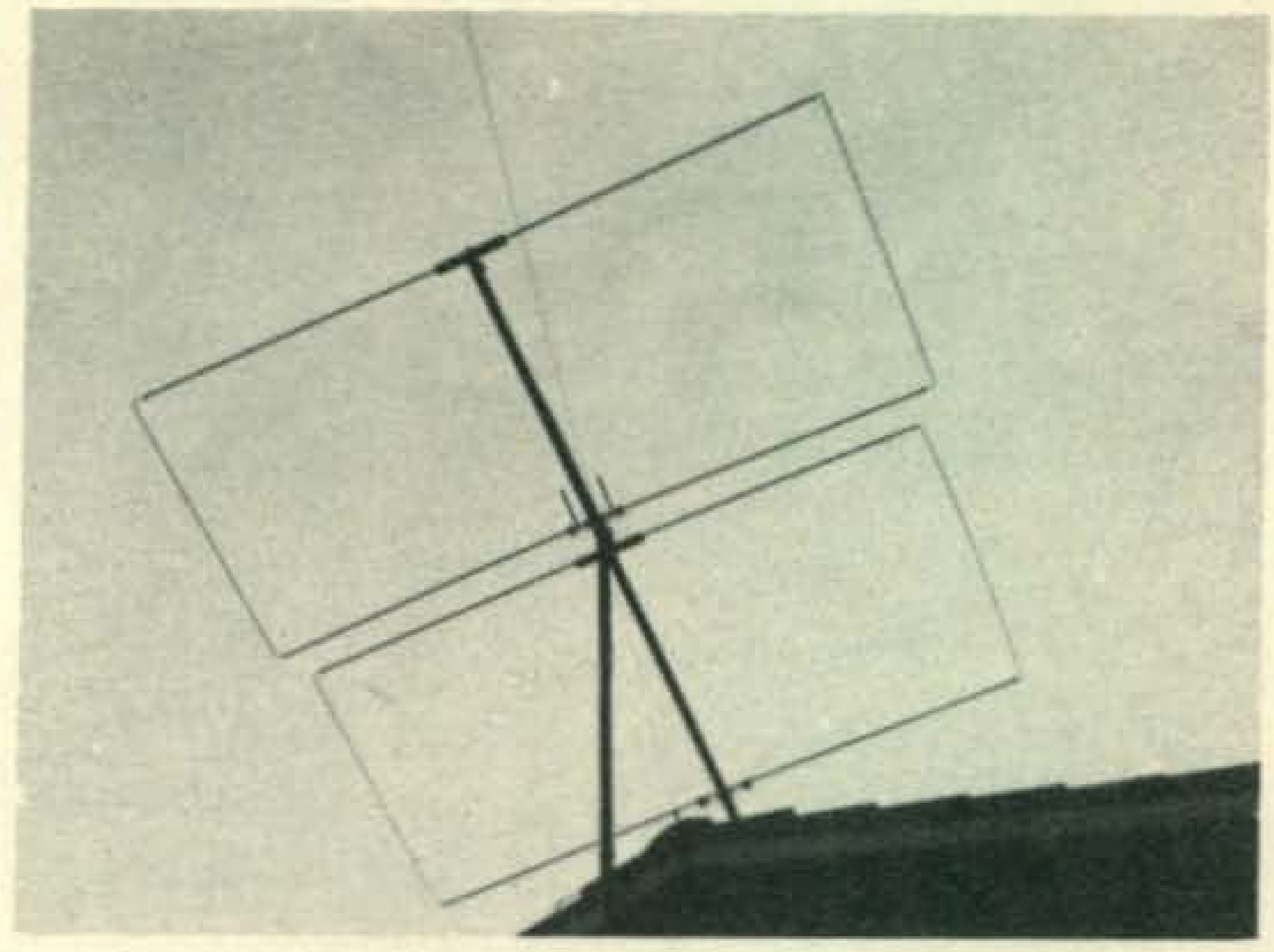


Fig. 2(B)—G3PTN's 2 element "mini-beam" ready for action. Note that small stubs have been attached to element 1 to permit easy adjustment for minimum s.w.r. When properly adjusted, antenna shows s.w.r. of about 1.1 at resonance (14.2 mHz), with s.w.r. reaching 2 at 14.0 mHz and 14.325 mHz. Input impedance of the antenna is close to 42 ohms, with a beamwidth of 70 degrees between the half-power points. Antenna design is covered by British Patent 26716, but amateurs may construct the beam for their own personal use. (*Photo courtesy G3PTN*).

He was right, a small knot of teeny-boppers were happily singing and jumping rope in cadence in a neighbor's backyard.

"The more it changes, the more it is the same," I remarked.

Pendergast turned around and reached for the headphones. "I suppose the same thing is true about amateur radio?," he demanded.

"Certainly," I said. "History repeats itself. Some of the best new ideas are revisions of old ones. Rhigi in Italy was generating microwaves in the Gay Nineties, the mechanical filter was first described in 1924 and single sideband was in limited use about the same time."

Pendergast interrupted, "And there's nothing new about antennas? How about the Log Periodic antenna? That's a new one."

"Yes," I agreed, "But the ancestor of the Log Periodic has been around for a long time. And there's a new version of this oldie today."

"Oh?," said Pendergast, turning off the transceiver and placing the headphones on the desk. "Tell me more. I'm an antenna nut, as you know."

I quickly drew a picture on the reverse side of the log book sheet (Fig. 1). "Here's a sketch of the so-called *ZL-special* antenna. It isn't very well known in the United States, but it is quite popular overseas. As you can see, the ZL-special can be thought of as a single cell of a log periodic antenna, which is composed of a group of ZL-special cells connected in sequence. The main difference between the two antennas is that each cell of the log periodic antenna is cut for a slightly different frequency, thus broad-banding the whole affair. This is a simplified viewpoint, of course, but it illustrates the validity of the ZL-special design. Basically, it is two half wave elements spaced 1/8-wavelength and directly fed, with a 135° phase reversal stub between elements. The odd-ball phasing produces a unidirectional pattern. A practical ZL-special beam has a front-to-back ratio of about 15 decibels and a power gain of about 3 or 4 decibels."

"I've heard about the antenna, but I've never seen one," said Pendergast.

"Well, phased arrays of this type have never gained much favor among amateurs in the United States. The parasitic beam has led the field, since it provides somewhat more gain per element than an equivalent phased array." I paused and reached for a magazine with a startling red cover.

"What's that?," asked Pendergast. "The latest copy of *Playboy?*"

"This is *Radio Communication*, the Journal of the Radio Society of Great Britain," I

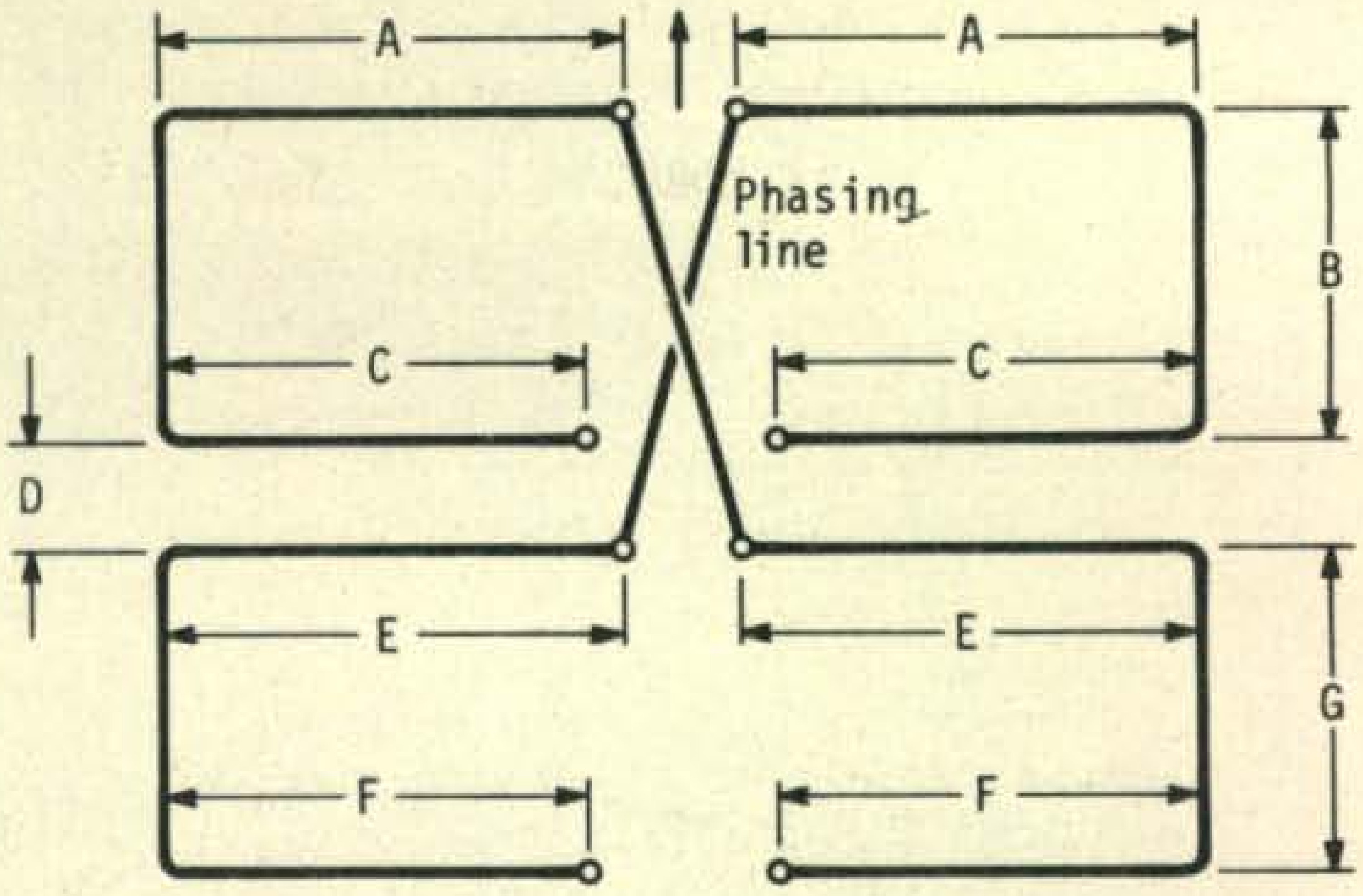


Fig. 3—Dimensions for G3PTN beam antenna for 10, 15, 20 or 40 meters.

Band	A	B	C	D	E	F	G	Phasing line
10	33½"	30"	33"	3½"	31½"	31"	30"	43"
15	50"	45"	49½"	5"	47"	46½"	45"	64½"
20	67"	60"	66"	7½"	63"	62"	60"	86"
40	11'2"	10'0"	11'0"	15"	10'6"	10'4"	10'0"	14'4"

replied. "A really great magazine. You should join the Society and get this publication."

"Is it written in English?," Pendergast asked.

I gave him a withering look. "Written in the King's English, as the saying goes. Don't try to be humorous." I turned to the June article by G3PTN.

"Here it is," I said. "The ZL-special antenna updated to 1973. The author has taken the original design, folded the elements into a rectangular loop and has come up with a compact, 20 meter mini-beam that has a turning radius of about 7 feet. Boom length is only 11 feet, and the maximum 'wingspread' of the beam is only 11'6". That's a pretty small beam antenna for 20 meters."

Pendergast sniffed. "How does it perform?"

"Well, G3PTN built two models of the antenna and made over 1,000 contacts with them over a period of a year. He compared his antenna to a V-beam and concluded his array had a forward gain of about 4 decibels and a front-to-back ratio of about 10 decibels. Here's what it looks like." I drew a second sketch in the log book (fig. 2).

"This is a top, plan view of the G3PTN array. The rectangular loops lie in the horizontal plane. They are made of ½-inch diameter aluminum tubing for the center sections and ¼-inch diameter tubing for the outer sections. Personally, if I built it, I would use slightly larger tubing for increased strength. In any event, the two loops are supported from a boom made of 2-inch diameter aluminum tubing, 11 feet long."

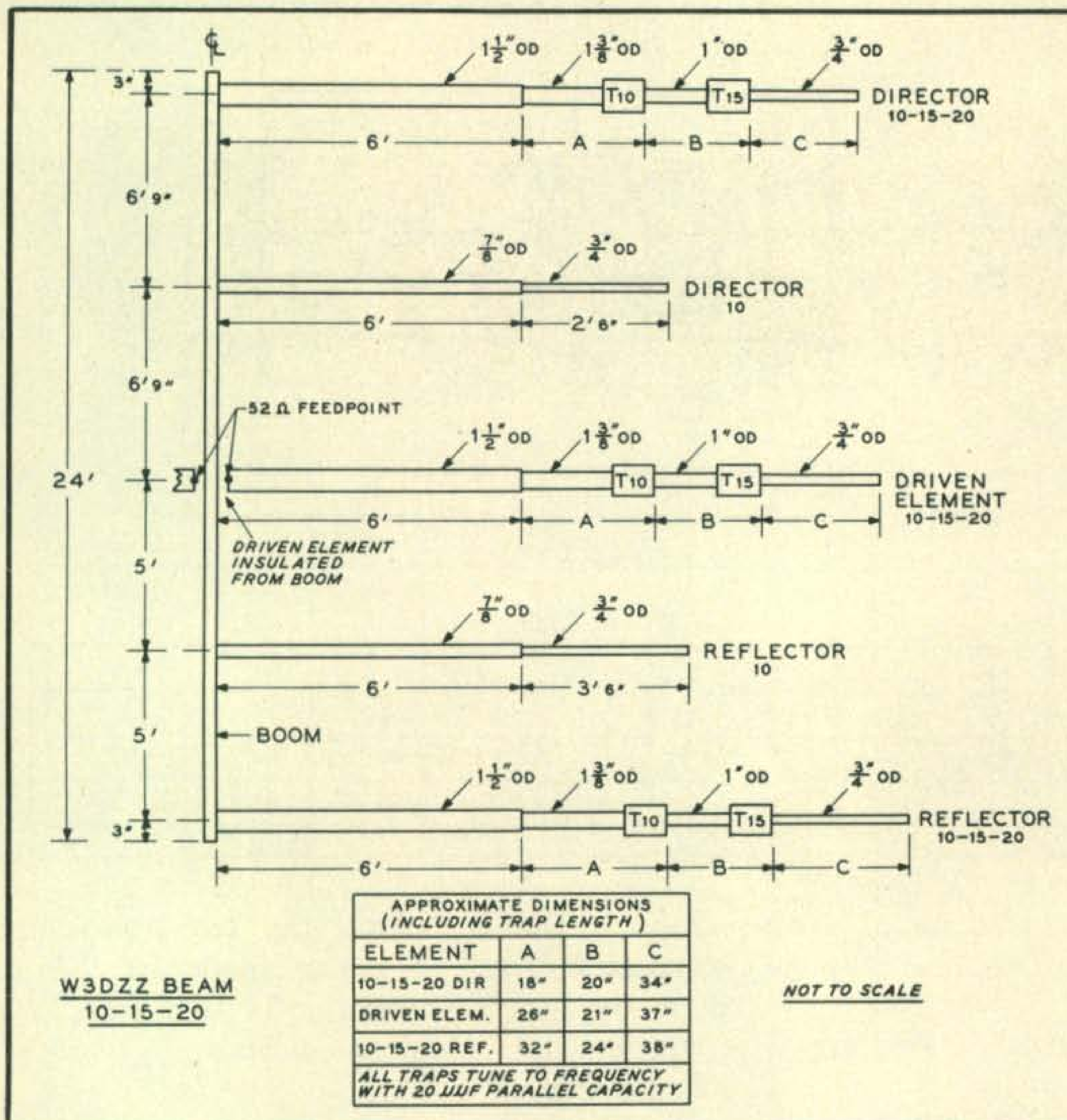
"And the element supports?," asked Pendergast.

"Like this," I said, rapidly drawing fig. 3. "The elements are clamped to a mounting plate by means of U-bolts and plastic insulators made of PVC tubing – you know, the plastic water pipe stuff. At the low voltage points, that is, where the feedline and phasing section are attached, the mounting plate may be made of aluminum. At the high voltage ends (the open ends of the elements) the mounting plate is made of insulating material. G3PTN used *Perspex*, whatever that is. I never heard of the stuff over here, but I suppose it is something like lucite."

I saw a glimmer of interest in Pendergast's eyes, so I continued. "The ends of the elements that are in close proximity at the center are aligned with an insulating dowel, so the two loops are fairly rigid. Electrically, they are connected together by means of a phasing line. The line is an 86" length of 300 ohm TV ribbon, with a half-twist in it. The combination of the twist and the line length provide the proper phase relationship between the two elements. The feedpoint is at the junction of the phasing line and element A. The input impedance of the beam seems to be about 48 ohms, so G3PTN used a 50 ohm coaxial line and a 1:1 ferrite balun for his feed system."

"Why the balun?," asked Pendergast.

"This is a balanced antenna and the



APPROXIMATE DIMENSIONS (INCLUDING TRAP LENGTH)			
ELEMENT	A	B	C
10-15-20 DIR	18"	20"	34"
DRIVEN ELEM.	26"	21"	37"
10-15-20 REF.	32"	24"	38"
ALL TRAPS TUNE TO FREQUENCY WITH 20 ΜΜF PARALLEL CAPACITY			

Fig. 4—Dimensions for original W3DZZ triband beam antenna (from *Beam Antenna Handbook).* Original W3DZZ beam had a 24 foot boom and extra director and reflector for improved front-to-back ratio on 10 meters. Driven element was directly fed from a coaxial transmission line. The line was wound into a multiturn coil directly behind the driven element to act as a sort of balun. Antenna feedpoint impedance was somewhat lower than line impedance so s.w.r. never approached unity on any band.

currents in both halves have to be symmetrical. The proper way to achieve this is to use a balun, which provides a balanced termination for a unbalanced transmission line."

"Damned clever," said Pendergast, carefully gathering up the sketches after tearing the pages from my logbook. "This looks like a great beam antenna for the amateur who needs a 'cover' or 'disguise.' It isn't much bigger than a channel 2 television receiving antenna."

"Right," I said. "And a 10 or 15 meter version is even smaller. In fact, you could use this idea to build a 40 meter mini-beam that would only measure 22 feet by 23 feet in size. That's about equal in overall area to a 3-element, fifteen meter beam."

"That would be a little more obvious," said Pendergast. "But it is a great idea. Its awfully hard to be loud on 40 meters when you live on a city lot."

"Well, here are the dimensions for 10, 15, 20 or 40 meters (fig. 3)," I said. "Take your pick."

"Any other pointers?," asked Pendergast.

"According to G3PTN element A should grid-dip to about 13.75 mHz and element B to 15.5 mHz with the phasing line removed. Also, changing the sides symmetrically by one inch changed the resonant frequency by about 100 kHz. At the frequency of resonance, the s.w.r. on the transmission line runs close to 1.1. S.w.r. is less than 2 across the 20 meter band. That pretty well sums it up, and I think it would be smart if you joined RSGB. It's a fine outfit and they have a topnotch magazine . . . . . in English," I added.

"Fair enough," said Pendergast. He hesitated, then said, "I understand that you are going to write an antenna column for *CQ*."

"Yes," I replied. "It seems so."

"Well," Pendergast said, "I hope you cover some basic antenna designs that are popular on the ham bands. There's a lot of confusion about Yagis and Quads and triband beams and too many self-appointed experts giving free advice on the air."

"It sounds as if you are setting me up as a target for brickbats," I replied. "But I certainly will try and answer some of the more common questions. I guess a lot will depend upon the mail I receive, and the questions asked."

"Alright," said Pendergast, "I'll ask the first question. Who invented the trapped, tri-band beam for 20, 15 and 10 meters?

Where did it come from?"

I reached up onto the top shelf of the radio shack, the one over the window, and pulled down a dusty magazine. "Read this," I said.

"This is the August, 1940 issue of *Electronics* magazine. On page 42 is an article entitled, 'A Multifrequency Tuned Antenna System,' written by Howard K. Morgan of Transcontinental and Western Air, Inc. The short article described a multi-frequency doublet used for reception of aircraft transmissions. The multi-frequency effect was achieved by placing parallel resonant traps at critical places in the doublet antenna. Undoubtedly Mr. Morgan is the grandfather of the trapped beam antenna. As far as I know, this is the only reference to this antenna system published before World War II."

"We should erect a monument to Mr. Morgan," said Pendergast. "I wonder if he was a ham, or not?"

"No way of telling," I replied. "In any event, in March, 1955 an article entitled, 'The Multimatch Antenna System,' by W3DZZ appeared in *QST* magazine. This was the introduction of the famous W3DZZ trap beam, which is the direct father of today's triband beam antennas (fig. 4). So you see that the triband beam has a long history and the principle of the trapped antenna system was well known in 1940, over thirty-three years ago."

"How did the W3DZZ antenna work? Was it any good?," asked Pendergast.

[Continued on page 90]

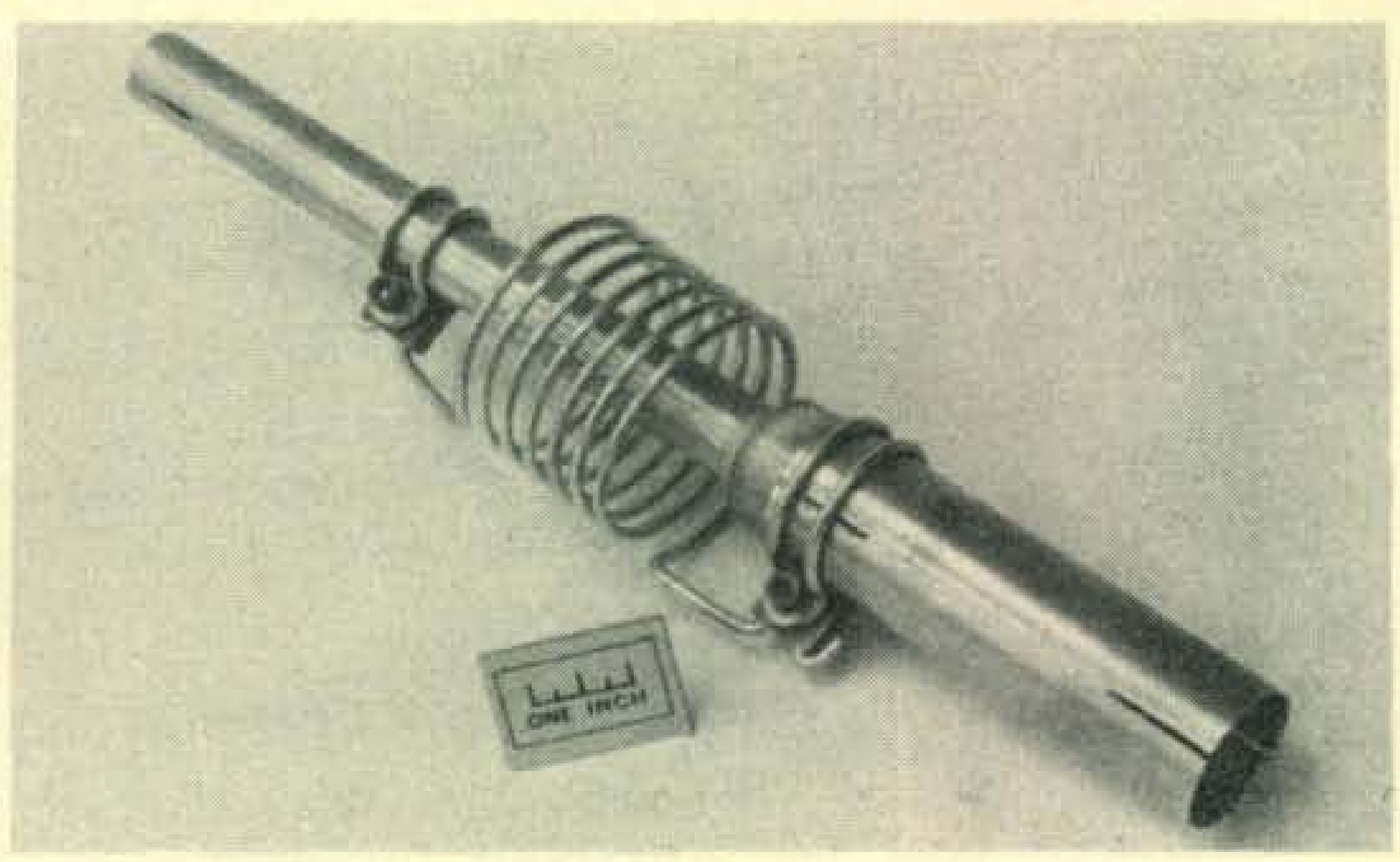


Fig. 5—The original W3DZZ trap element. This high-Q trap is wound of #8 aluminum wire. The coil is 3" in diameter and 3" long. The 15 meter coil has seven turns (shown here); the 10 meter coil has five turns. The coaxial capacitor is at the right and is 20 to 24 pf. Inner dielectric projects about one inch beyond the outer tube to form a long path to prevent breakdown across the dielectric.

noise immunity characteristics. Reducing the capacitance will tend to reduce lock-in time, but will make the circuit more susceptable to noise. With the values shown I have never had the volume "reduce" except when an actual SSTV signal was being received. Deep QSB and strong QRM during an SSTV transmission will bring the volume back up again. I don't normally find this objectionable because the picture is messing up at the same time, and I want to hear what's going on. The loop bandwidth is too narrow to lock both 15 Hz, and 16 2/3 Hz line rate signals. If your DX SSTV contacts are solid enough so that you want this feature, a switch and a second 10K frequency adjust trimmer pot could be added.

A Cheap "Balanced" Phone Patch

When using VOX it is important that the signal going *to* the phone line (receiver output) does not reach the transmitter input many db higher than the incoming signal *from* the phone line. This is also true if you want to put both ends of a phone conversation on the air at the same time. Most patches that separate incoming from outgoing audio use expensive hybrid transformers. Figure 4 shows another approach. Basically, Q_1 acts as a buffer amplifier for the signal going to the phone line. The "secret" lies in the operation of Q_1.

The outgoing signal appears at the emitter of Q_1; it also appears at the collector, but out of phase. It should be apparent that at some point on the BALANCE pot these out-of-phase voltages pretty well cancel out, and little of the outgoing signal reaches the input of IC_1. Q_1 acts as a grounded base amplifier to signals *from* the phone line. With this type of amp, the emitter and collector voltages are *in* phase, so there is no cancellation and a healthy signal reaches the input of IC_1.

The BALANCE control should be adjusted for the deepest possible null of the outgoing signal at the IC_1 output, while making an actual phone call. The depth of the null will depend upon how flat the phone line impedance is across the audio band, and how reactive it is. I obtained a very adequate null with the circuit shown. If you want to do even better, or have a high capacitance phone line, try putting some trial capacitors from the collector of Q_1 to ground; then adjust BALANCE. (Try 0.02 or 0.033 mf as a start, and go up and down from there.)

'Til next month. Vy 73, Cop, WØORX

Antennas [*from page 63*]

"Yes," I replied, "It was a good antenna. The boom was 24 feet long and the elements were very long for a trapped beam. The traps were made of airwound, aluminum coils, about 3 inches in diameter (fig. 5). The capacitor was a coaxial affair, made of two sections of aluminum tubing, with some kind of plastic poured between the tubes and allowed to set. Actually, the capacitor was the weak link in the design as the plastic broke down under the ultraviolet radiation from the sun. It crazed and cracked, moisture got into the cracks and eventually the capacitor blew up, especially if you were running high power. A lot of hams who swore by the W3DZZ beam rebuilt the capacitors with Teflon insulation, and some of these 15 year old beams are still going strong today. The W3DZZ design is a great beam for the home builder and if you have a junkyard of aluminum tubing and plenty of time, you can build a triband trap beam."

I rummaged in the drawer of the operating table and handed Pendergast a sketch of the W3DZZ antenna.

"The big problem, of course, is building the traps so that they stand up in bad weather and making the whole assembly strong enough to withstand winds. It isn't easy, but it can be done. Your reward is a beam having very efficient traps, very low loss, and – one would assume – a high figure of power gain."

"Is it difficult to adjust the traps?," asked Pendergast.

"No," I replied. "The completed trap is grid-dipped to the design frequency. Place the trap in the open, away from metal objects, and grid-dip it, using loose coupling to the grid-dip oscillator. Monitor the oscillator in a nearby, well calibrated receiver. Make each measurement about 5 times and take the average figure from the 15 meter traps to 20.5 mHz. After adjusting the traps by squeezing and expanding the coil, the devices can be placed in the antenna elements with no further adjustment."

"Why are the traps tuned outside the low end of the ham bands," asked Pendergast.

"A good question," I replied. "The only answer is that it has been found by experimentation that best antenna operational bandwidth and lowest s.w.r. across the band is achieved when the traps are tuned up just outside the low frequency end of each band. Maybe it is because the trap has physical

length to it, which tends to lower the measured frequency below the actual resonant frequency of the trap, assuming it had no physical size ..... or something."

"You don't sound very sure of yourself," observed Pendergast. I laughed. "My motto is, 'Often in error, never in doubt.' My information is free, so take it for what it is worth."

We stood up and looked out of the window of the radio shack. The sun was beginning to set now. The little girls were still jumping rope on the soft grass and their chant floated in the open window .....

"Down by the ocean ..... down by the sea
Johnny broke a bottle and blamed it on me.
I told Ma ..... Ma told Pa
Johnny got a spankin' so ha, ha, ha!"

DX *[from page 73]*
QSL Information

The following QSL information is courtesy of "The West Coast DX Bulletin".

A35FX–Via ZL2AFZ
A51PN–Via W1JFL
CN8BO–Via W4GKE
CR7GJ–Via W3HNK
CR8AM–Via WB6BGO
C31HB–Via DL8NU
C31GW–Via F5EQ
CT2BG–Via WA2BCK
C31BL–Via F3KJ
EL4B–Via K8LUH
EP2DO–KL7BJW
F0AVG/FC–Via DK5OS
FB8XC–Via F2MO
FB8XZ–Via F2MO
GC3PYK–Via WA1KYW
HZ1TA–Via HZ1HZ
HL9VR–Via K4CIA
HI8LC–Via W2KF
IBØPV–Via IØPV
JW1SO–Via LA1RO
JTØAE–Via OK3YAO
JD1AIV–Via JA3GZN
KC6SX–Via JH1ECG
KB6CU–Via WB6IKI
KJ6DI–Via K4RHU
KH6HDB/Kure–Via WA3HUP
MP4BJR–Via K9KXA
MP4BIN–Via WB2FVO
OZ8WH–Via W2BBK
OX5AY–Via K9YPW
PJ8AA–Via W2BBK
SV0WY–Via K0UOP
TU2DO–Via WA2DHF
TU2DV–Via WA6NFC
TU4AG–Via WA6NAM
VP1EG–Via K7DVK
VK9DH–Via W6LYC
VK9MC–Via K6ZDL
VK9DV–Via WA7OMZ
VP2KX–Via WA2IUV
VP2VAV–Via K4CDZ
VS5MC–Via DK5JA
WP2MAP–Via K2JOX
XW8FB–Via W3KT
YJ8BD–Via I0IJ
YK1ØK–Via OK2QF
ZF1KXJ–Via WA0KXJ
ZF1FBI–Via WA2FBI
ZD9GC–Via ZS6XO
ZS3AK–Via DJ9FH
ZK1AI–Via W6KNH
ZK1TA–Via W6KNH
3V8CA–Via F6CLW
3D2FM–Via W7YBX
3A2GX–Via I1ALX
3B6CF–Via JE1CKA
4M1A–Via YV1LA
4X4BL–Via WB2EDV
5R8AC–Via W3ABC
5W1AU–Via W6KNH
7P8AM–Via G3SGK
7Q7DW–Via G3AWY
8P6AC–Via 4S7YL
9G1HE–Via VE3FCL
9M8FDS–Via GW3OJB
9U5CR–Via ON5TO
9X5VA–Via W2PPG
9X5NA–Via W7LFA
DA1SI–Via C. Signer, Box 775 FSB, APO NY 09742

73, Jerry, WA6GLD

ANTENNAS

BY WILLIAM I. ORR, W6SAI

"CUBICAL Quad-Topic Number One!" read the headline in the December, 1948 issue of *CQ* magazine. And the headline is true today, for the Quad beam antenna is still a topic of conversation whenever DX operators gather, in person or on the air.

It is interesting to review the story of the Quad and to examine some of the more exotic versions of this popular antenna that have evolved over the years. A search of the literature reveals no information published on the Quad before World War II. Research conducted by W6SAI some years ago indicated that the Quad antenna concept was the brain-child of W9LZX, who at that time was the chief engineer of shortwave broadcast station HCJB in Quito, Ecuador[1].

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[1]Orr, "All About Cubical Quad Antennas", Radio Publications, Inc. Wilton, Connecticut.

The Quad was thought up to solve some antenna problems that were unique to HCJB and other tropical shortwave broadcast stations. As HCJB operated on several shortwave bands, numerous beam antennas were needed and these had to be as compact as possible due to the unavailability of land for an "antenna farm."

The first solution was to try a parasitic Yagi antenna, which was a failure as the combination of high transmitter power and the high-Q antenna produced destructive corona discharges about the tips of the antenna elements in the humid, tropical atmosphere.

The solution derived by W9LZX was to design a beam antenna that—quite literally—had no end tips to the elements. The loop, or Quad element, was the answer. The concept was derived from a folded dipole, fig. 1 (A). W9LZX "pulled open" the dipole to form a diamond and added a parasitic reflector element to it, fig. 1 (B).

Amateurs Use The Quad on Ten Meters

The antenna proved to be a success and word of the new design was quickly spread by the amateur operators at HCJB. The first amateur-built Quad antennas appeared during the period 1947-48 on the 10 meter band and, in the winter of 1948, both *CQ* and *QST* magazines printed the first build-it-yourself Quad information that dispelled some of the fanciful rumors about the antenna. The November, 1948 *QST* article discussed the theory of operation of this unique

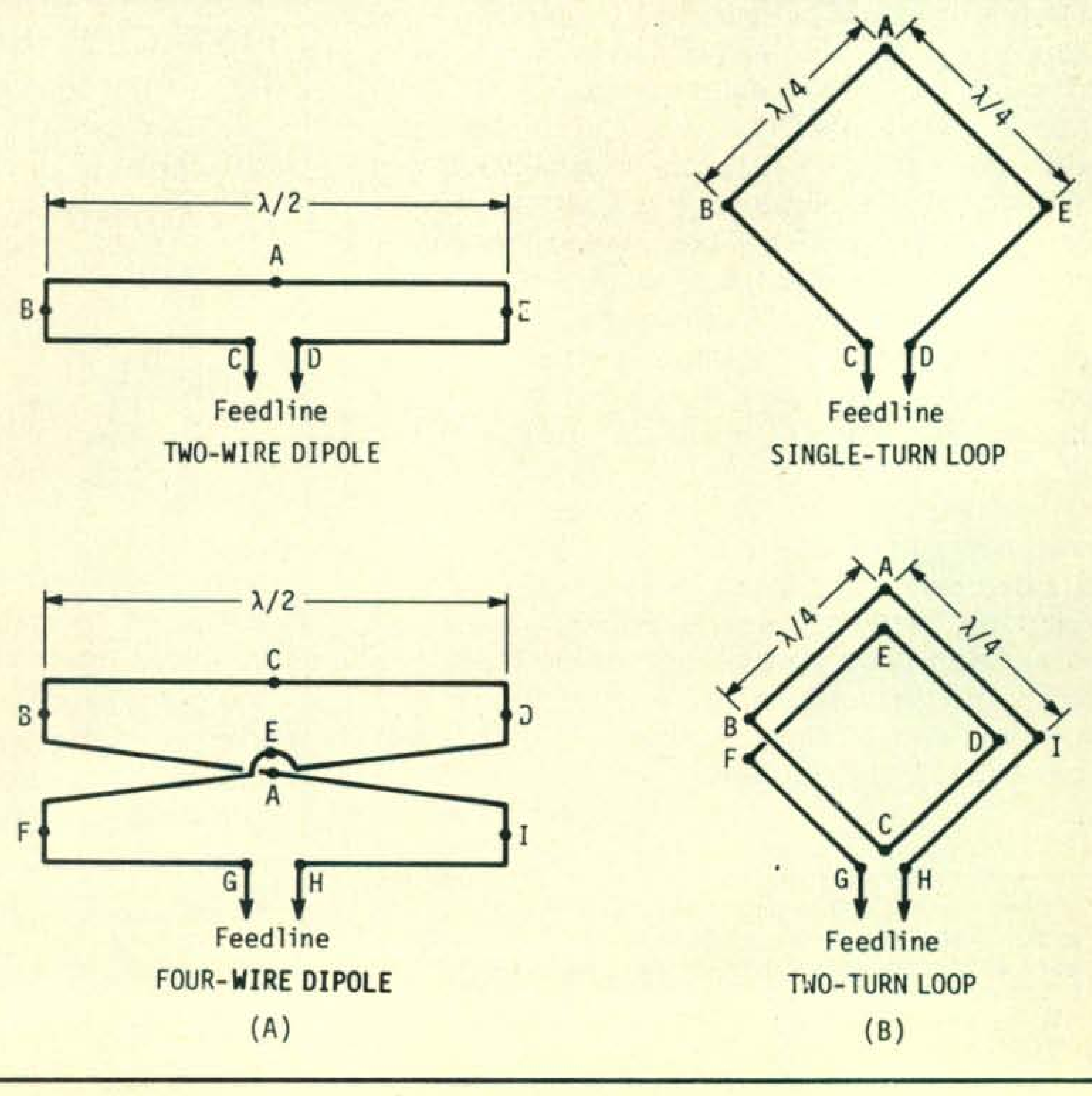


Fig. 1 — Cubical Quad antenna of W9LZX was derived from "pulled-open" folded dipole. (A) Two-wire dipole and four-wire dipoles are opened into single-turn and two-turn Quad loops (B). Equivalent points on the antennas are labelled for clarity.

antenna, fig. 2.

The HCJB design was adapted from a four-wire folded dipole and both reflector and driven element of the original Quad were double loops, to boost the radiation resistance of the antenna high enough to match a two-wire, 600 ohm transmission line, popular in those dear, dead days of shortwave radio. The *QST* article reported that a model Quad built for 144 mHz tests provided about 7.5 decibels power gain over a reference dipole. The article also voiced the suggestion that there appeared to be no reason to use a two-wire configuration for the reflector, as it was only an expedient to make the input impedance of the driven element assume a desired value.

The December, 1948 *CQ* article dealt more with the nuts-and-bolts construction of a practical 10 meter Quad beam, rather than with the theory of operation, fig. 3. The article discussed the 10 meter Quad design of W8RLT. The theoretical gain of the Quad was estimated to be 5.5 decibels, but *CQ* noted that the claimed gain approached 11 decibels! Viewed in the light of today's experience with the Quad, it appears that the actual gain of a properly adjusted 2 element Quad is in the vicinity of 7 decibels.

The Quad antenna continued to be a popular amateur array until the "tri-band," trap-tuned 3 element Yagi beam arrived upon the scene. It quickly eclipsed the single band Quad, until it was later found that three Quad antennas could be interlaced on one structure for operation on 20, 15 and 10 meters.

Today, the Quad antenna is as popular as ever, and this column investigates some of the more interesting applications of this unusual antenna.

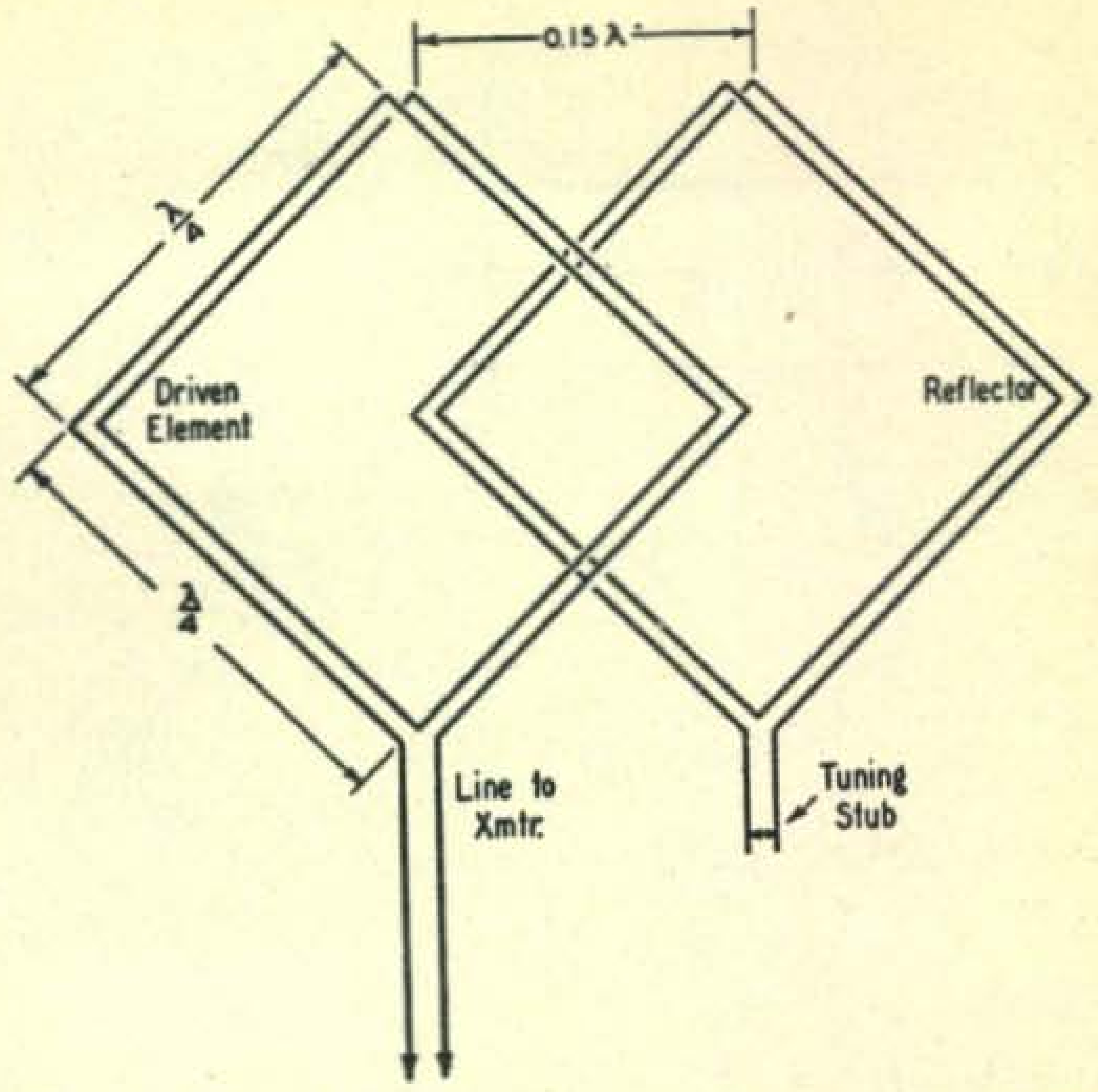


Fig. 2—Quad drawing shown in November, 1948 *QST* magazine. Two-wire loops were used for both reflector and director, with adjustment stub provided in reflector loop. Model Quad was tested on 2 meters and judged to have a power gain of 7 decibels over dipole.

The "Pulled Open" Folded Dipole

The idea of the "pulled open" folded dipole conceived by W9LZX was a valid principle. Two- and four-wire dipoles opened in this fashion are shown in fig. 1 (B). The radiation resistance of either loop is lower than that of the parent dipole. The radiation resistance of the two wire dipole is about 288 ohms and that of the resultant single turn loop is about 140 ohms. The figures for the four wire configuration are about 1200 ohms and 600 ohms. Each diamond-shaped loop provides a power gain of about 1.4 decibels over a dipole, or 3.2 decibels gain over an isotropic radiator.

The folded dipole may be distorted into a square or a circle, or any other open shape and the characteristics will remain reasonably close to those exhibited by the diamond-shaped loop.

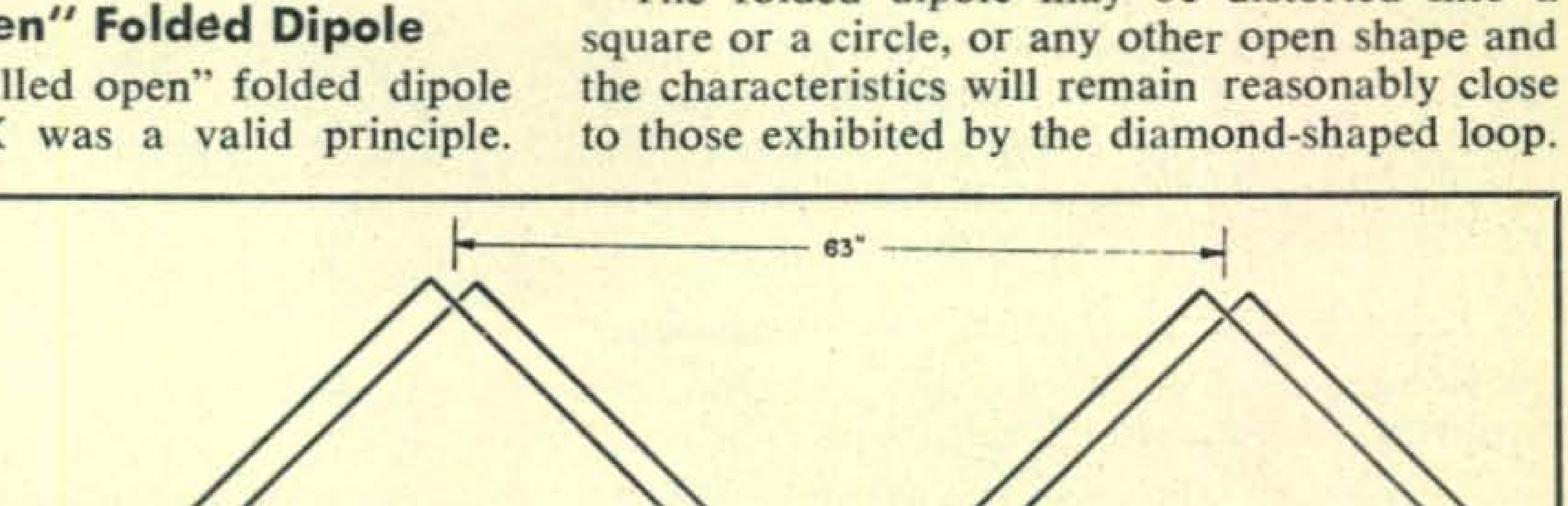


Fig. 3—CQ magazine provided construction data on Quad built by W8RLT in December, 1948. Dimensions shown are for 10 meter band. Reflector was tuned by combination of adjustable stub and tuning capacitor.

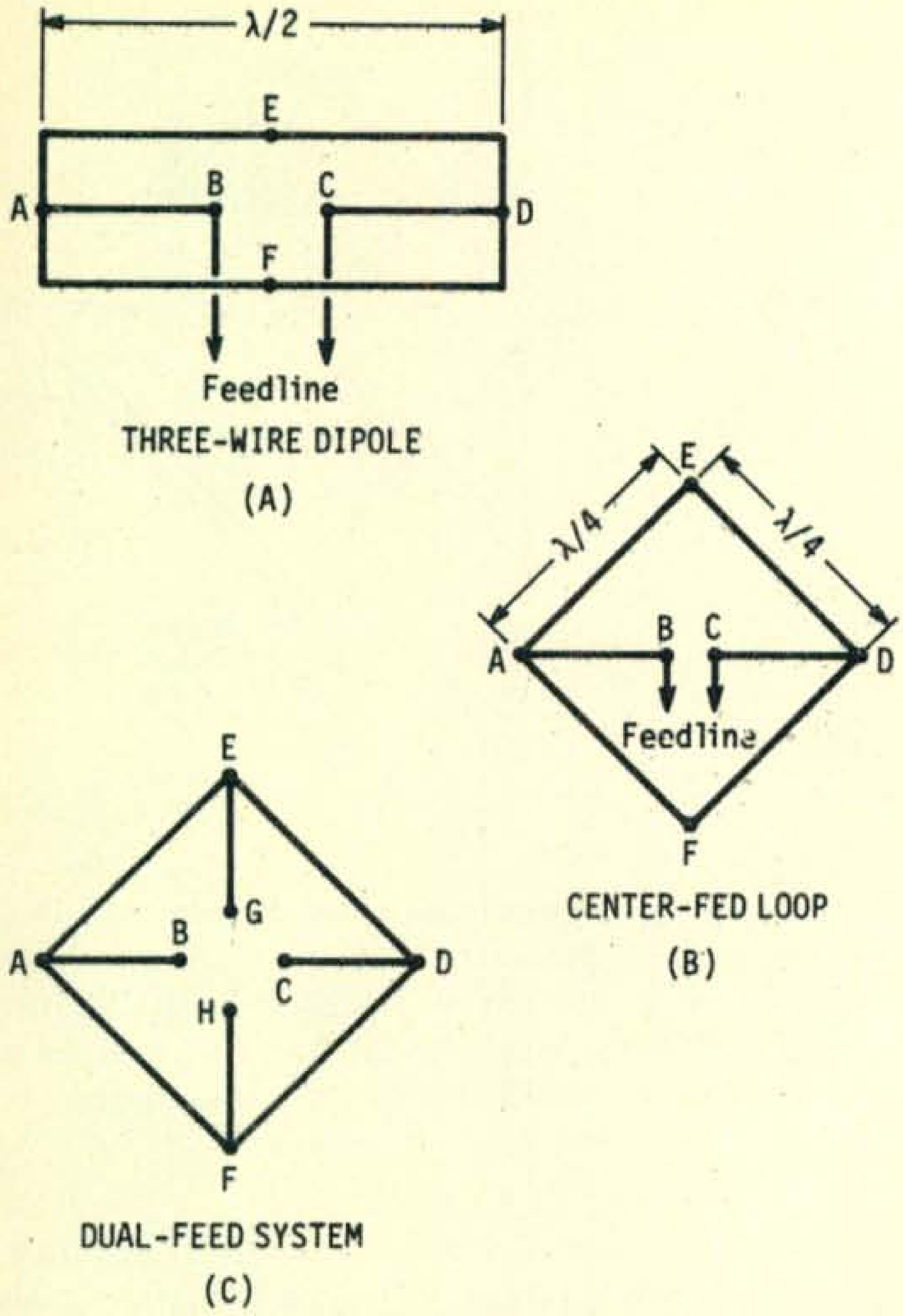


Fig. 4—Three-wire folded dipole may be opened into loop, leaving center wire for feed system. (A) Dipole with equivalent points indicated. (B) Center-fed Quad loop made from three-wire dipole. (C). Additional set of feed wires added at points E and F. Loop may be fed at points B and C for horizontal polarization or points G and H for vertical polarization.

The radiation pattern of any of these configurations is a slimmer version of the dipole radiation pattern, but includes a small vertically polarized lobe at right angles to the main lobe, caused by a minor amount of radiation from the vertical wires of the configuration.

A Polarization Trick With the Quad Loop

An interesting variation of the Quad loop can instantly provide either vertical or horizontal polarization at the wish of the operator (fig. 4). Drawing (A) is a conventional three wire folded dipole, driven in the center wire. This device has a radiation resistance of about 650 ohms. Drawing (B) shows the dipole pulled open, to provide a Quad loop, driven at the center of the middle wire. The loop is horizontally polarized and has a radiation resistance of about 300 ohms.

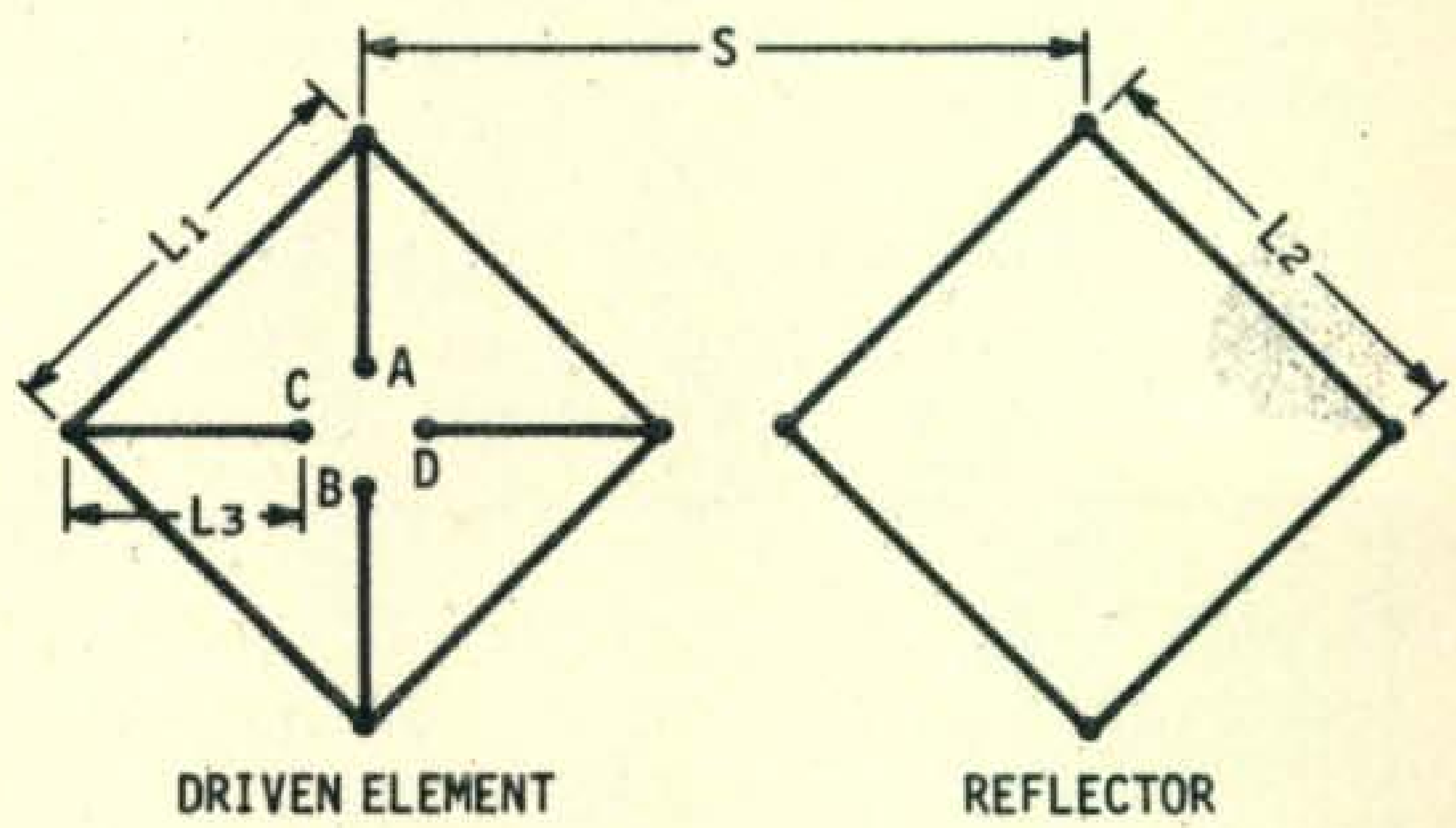
A second set of feed wires are added, shown in drawing (C) which are attached at the top and bottom points of the loop and terminate near the center. If the loop is fed by these vertical wires, instead of the horizontal wires, the characteristics of the loop remain unchanged, *except that the polarization has shifted from the horizontal to the vertical plane.*

Experiments have shown that radio waves reflected from the ionosphere arrive at a receiver with random polarization and the ability to change polarization of the receiving antenna at the flick of a switch can often improve the readability of a weak signal by a large factor. In like manner, the ability to switch antenna polarization during a transmission period can be helpful over a difficult communication circuit, as it is possible that fading can be substantially reduced.

The loop of fig. 4 may be easily cross-polarized by the addition of a double pole, double throw relay at the center to connect the transmission line to either the vertical or the horizontal feed wires. If the loop is used by itself, with no parasitic elements, the 300 ohm balanced feedpoint may be converted down to a 70 ohm unbalanced transmission line by means of a simple 4 to 1 ferrite core balun.

The "Flip-Flop" Quad Beam

Parasitic directors and a reflector can be added to the cross-polarized loop shown in fig. 4. If the parasitic elements are cut to the correct size, they require no adjustment stubs. The parasitic elements are thus symmetrical and "don't know" the polarization of the driven element. Hence, they need not be switched or otherwise adjusted when the polarization of the driven element is switched from horizontal to vertical or vice-versa. A set of representative



Band	L_1	L_2	L_3	S
20	17'8"	18'2"	12'6"	8'5"
15	11'8"	12'3"	8'4"	5'7"
10	8'8"	9'1"	6'3"	4'2"

Fig. 5—The "Flip-Flop" Quad beam. Either horizontal or vertical polarization may be chosen by placing a double pole, double throw switch at center of driven element so feed system is attached to either points C,D or A,B. Reflector element requires no switching. Since center elements (L_3) of driven element are shorter than outside elements (L_1), feed-point will display reactance. Addition of small inductors to elements L_3 will cancel out reactance.

dimensions for a two element "Flip-Flop" Quad beam for the various high frequency amateur bands is given in fig. 5. The feed point impedance is approximately 200 ohms, and a 4 to 1 balun may be used with a 50 ohm feedline.

The horizontal and vertical feed "wires" can easily take the form of the supporting arms of the cross-polarized loop and the whole driven element may be made up of horizontal and vertical aluminum arms supporting a wire loop strung from tip to tip of the cross-arms. (A six element version of this flip-flop design has been for sale to hyper-active CB operators for some time and an amateur experimenter could easily cut one of these "store-boughten" CB arrays down to size for 10 meter operation.)

The Delta Quad

In recent months the so-called delta Quad has received quite a bit of publicity, its excellence being extolled in various amateur magazines. In brief, the delta Quad is an array composed of triangular shaped elements, usually positioned with the apex of the triangle oriented down (fig. 6). The triangular shape seems to exhibit the same degree of gain over a dipole as does the square or diamond shape, and the radiation resistance is nearly the same as the other versions. Accordingly, the virtues of this configuration seem a bit obscure to the writer and, unless there is some mechanical advantage to using a delta Quad, it would seem easier for the experimenter to build the more common square or diamond shaped array.

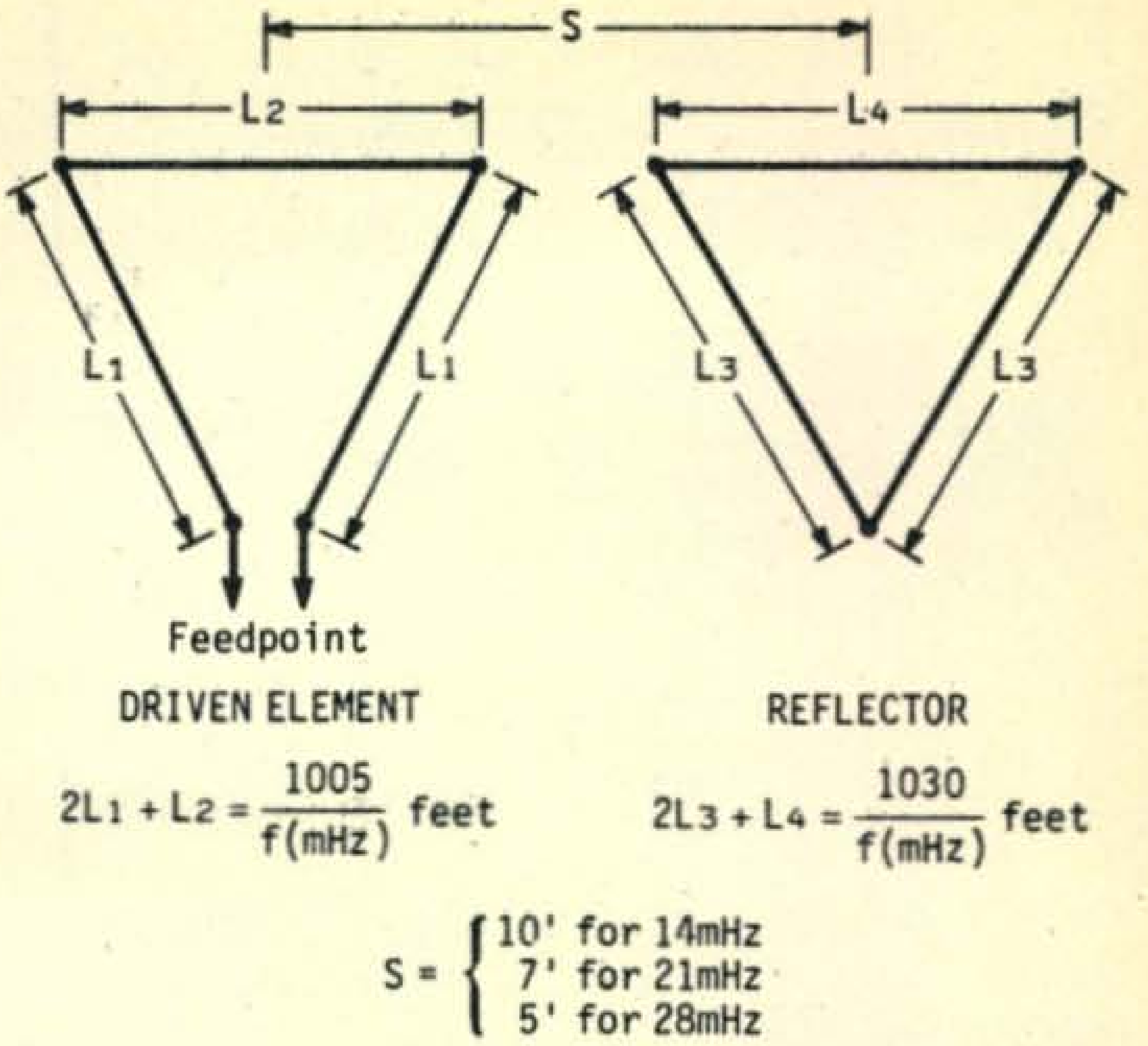


Fig. 6—Dimensions for Delta Quad array for 20, 15 and 10 meters. Length of sides is relatively unimportant as long as total side length works out according to formula. Usua design is to make sides L_1 and L_3 out of tubing and string side L_2 (wire) between tips of elements.

The Swiss Quad

Another version of the Quad beam is the Swiss Quad, no doubt first used by a Swiss amateur! This interesting device is shown in fig. 7. The Swiss Quad is an all-driven array, with horizontal, tubular elements crossed at the center and vertical elements made of wire. Properly built, it is a rugged affair and is very popular in Europe. Both loops are fed at the bottom by means of a T-match (double gamma match) and the antenna bears a striking resemblance to two stacked W8JK beams, connected together at their element tips.

On-the-air tests indicate that the Swiss Quad has a gain figure comparable to the more common 2 element Quad design, with a deep null off the back.

One advantage of this design is that the crossover point of each element is grounded to the supporting structure, a comforting feature to amateurs in areas having heavy lightning storms, as the antenna is inherently lightning-resistant.

The balanced-T matching system is fed with a 300 ohm line, or with a balun and coaxial transmission line. While the original Swiss Quad design included no resonating capacitors in the T-match bars, it is suggested that they be included. Length and spacing of the T-match and capacitor settings are adjusted for lowest s.w.r. on the transmission line.

A 24 Element Quad Array!

W9LZX does it again! Clarence Moore has designed, and has in operation a new, giant Quad beam antenna, shown in figures 8 and 9.

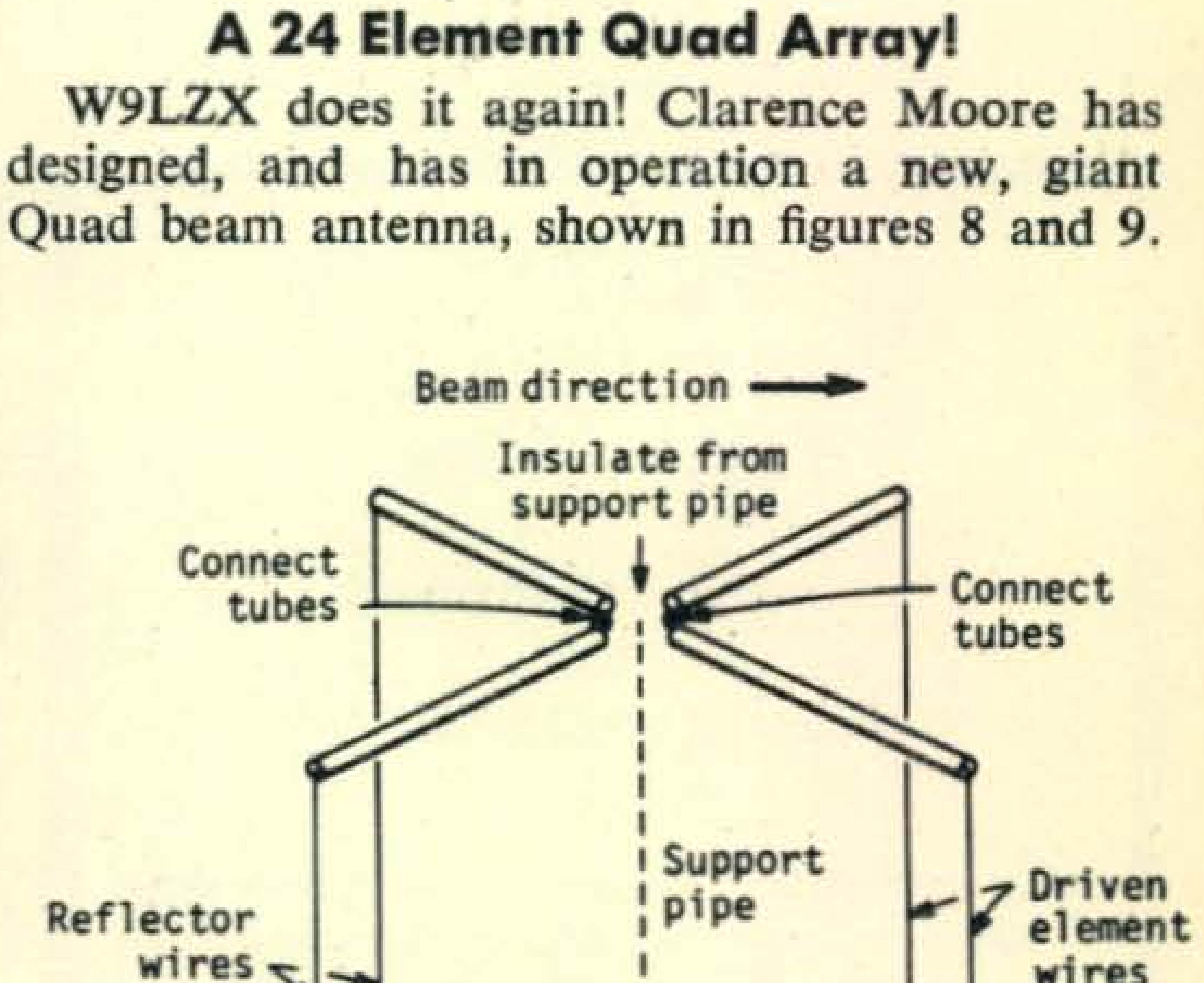


Fig. 7—Dimensions for Swiss Quad Antenna. Horizontal arms are made of aluminum tubing, with vertical sides made of wire strung between tips of tubes. All center points are insulated from the support pipe.

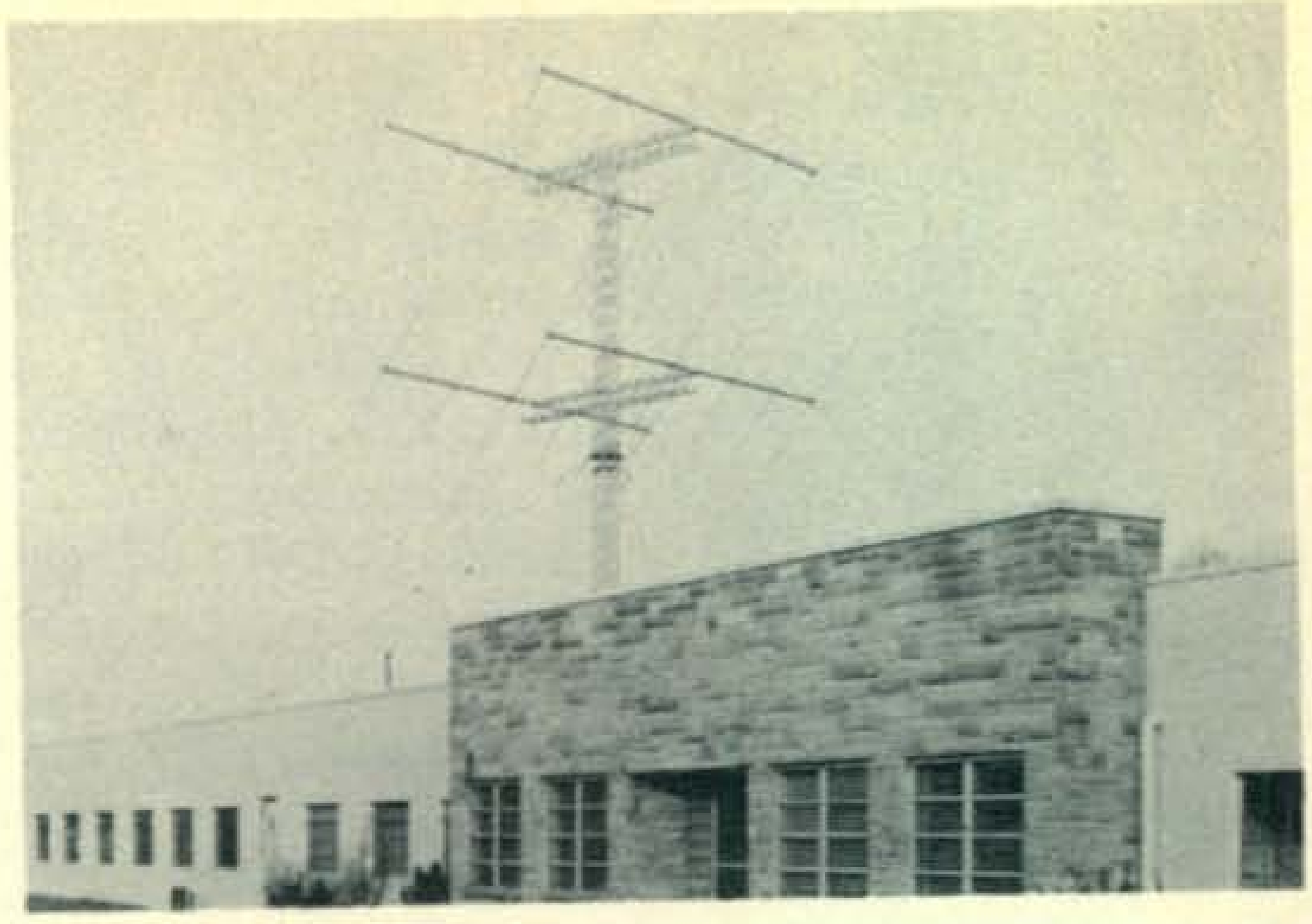


Fig. 8—Latest "monster" Quad array of W9LZX! Super-antenna is composed of four, six element Quads, each on a 40 foot boom. Quads are spaced a half-wavelength apart, held in position on two 45 foot horizontal booms made of triangular mast structure. Claimed gain of antenna is 23 decibels!

The array is composed of four, six element Quads, each on a 40 foot boom! The Quads are spaced a half-wavelength apart, and are held in position on two 45 foot horizontal booms made of triangular mast structure. The claimed gain of the array is 23 decibels as compared to a reference dipole!

The complete assembly shown in fig. 9 is a 15 meter antenna used by W9LZX at his laboratory (Crown International, Mishawaka, Indiana). A single six element Quad, one of four used in a similar giant array is shown in figure 9.

A Call for 80 Meter Quads!

Several amateurs have expressed interest in the erection of a Quad antenna for 80 meters. The author has heard of the existence of such monsters; indeed the 80 meter Quad of K3JH is shown in the *Quad Handbook*[1]. If the owners of some of the monster Quads will kindly step forward and identify themselves, I will be pleased to receive details of operation and construction for inclusion in this column at a later date.

73, Bill, W6SAI

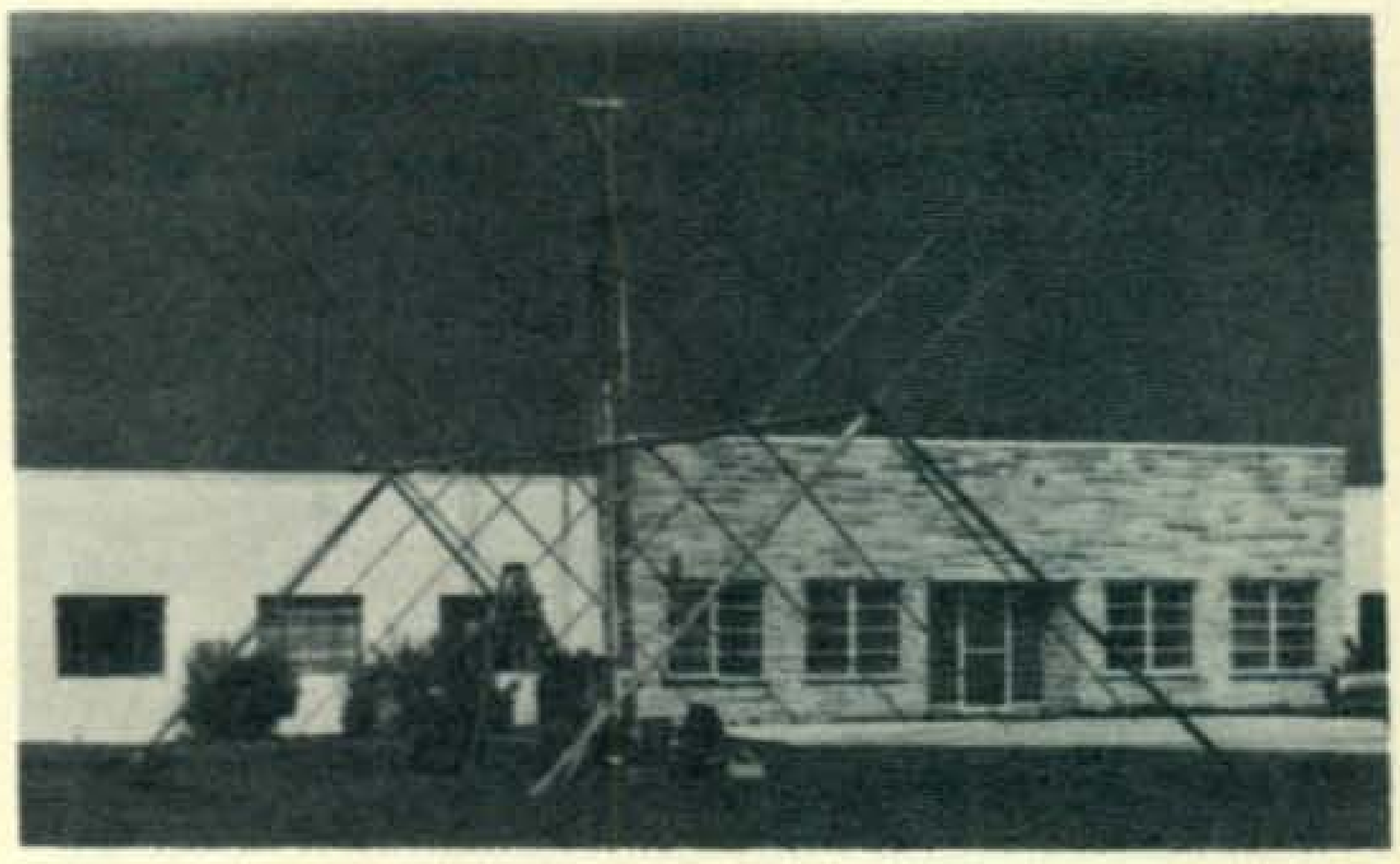


Fig. 9—Single, six element Quad rests in supporting structure while W9LZX puts finishing touches on assembly.

ANTENNAS

BY WILLIAM I. ORR, W6SAI

"No more about Ye DX Bands
Do Wild Men Push and Pull,
Or brag about 3A's, TJ's
Or toss about Ye Bull.
Ye sunspotte count Hath Gummed
Ye Game,
Ye bands are Dry as Snuffe,
And many a Hardy Soul, no doubt,
Doth find it hard to do Without,
Except Thee and Me, Olde Scout,
Who Never worked Ye Stuff."

*48 Campbell Lane, Menlo Park, CA 94025.

"Where in Heaven's name did you get that bad poetry?", I asked Pendergast as he breezed in the door and slid gracefully into my favorite armchair.

"Written about 1938 by that great minstrel of 20 meters, W1DX", replied Pendergast. "I will copy it into your logbook so you will always have it at your fingertips."

"Forget it," I said. "I can't understand why you are quoting poetry instead of working DX. Have you given up the chase?"

Pendergast settled more comfortably into the chair and looked me squarely in the eye. "Ten-four, old buddy," he said. "I've left the merrie 20 meter band and am now a big-time operator on 2 meter f.m. with a rice-box and a brick. Behold!" He thrust a 10 watt, 12 channel f.m. transceiver and an amplifier under my nose, cables dangling from the units like a dead octopus.

I recoiled slightly, as one would from a dead octopus, and asked my erstwhile DX-companion why he had made such a startling change in his life-style and operating habits.

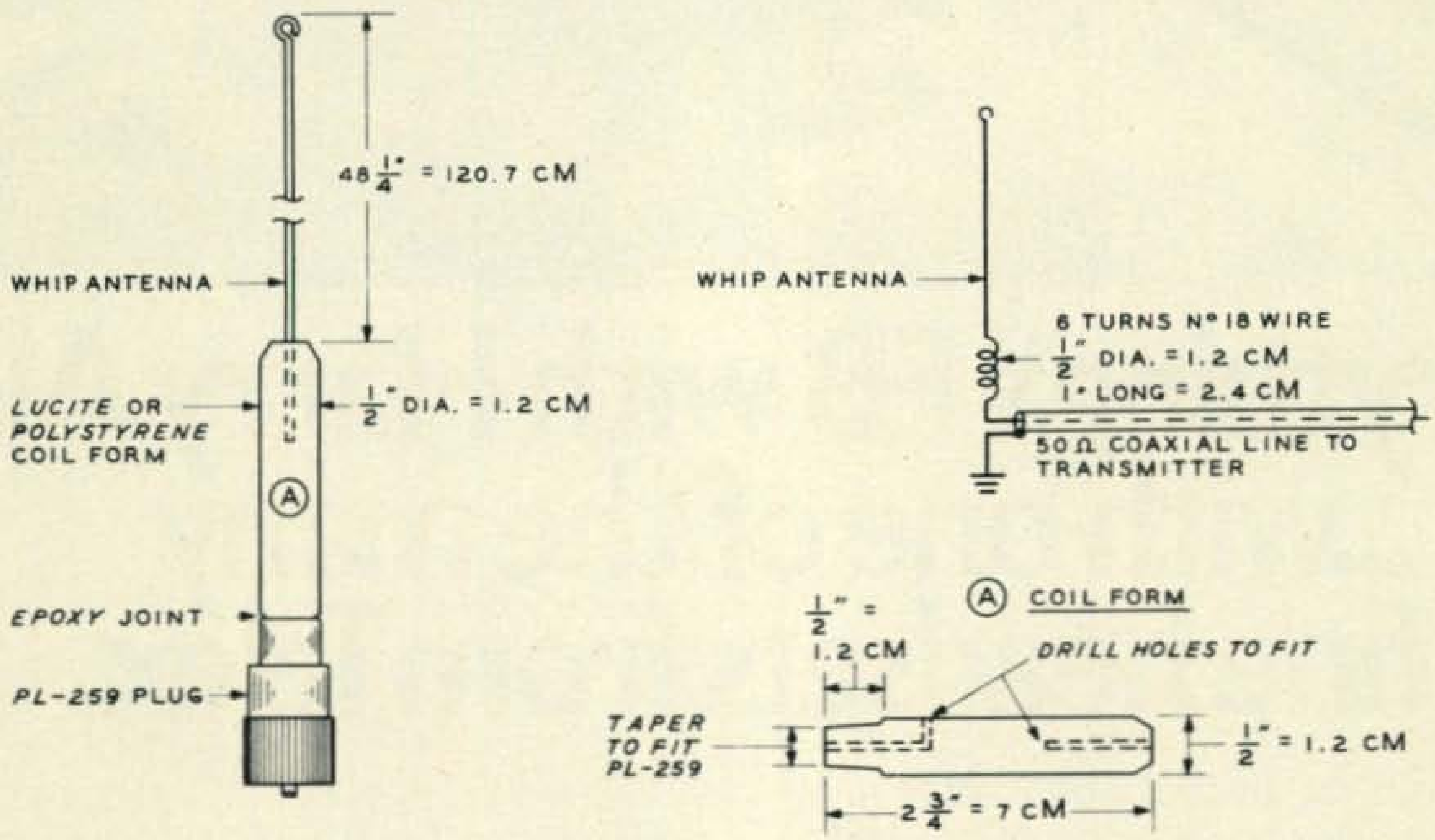


Fig. 1—A simple gain antenna for 2 meter mobile f.m. The ⅝ wavelength whip is assembled from a PL-259 coaxial plug, a plastic coil form and a modified CB whip antenna. The whip is cut to length and fitted into the end of the coil form which is mounted in the open end of the plug. The small matching coil is wound on the form. Whip, coil form and plug are firmly joined with epoxy cement.

The coil form is drilled at one end to accept the whip and the other end is drilled to pass the wire connection from the plug to the coil. The wire is "fished" through the side hole and wound into a small six turn loading coil.

The coil form may be turned out of lucite, polystyrene or other plastic. One end makes a force-fit into the coaxial plug. Before the coil is pressed into the plug, a short length of wire is soldered to the center pin of the plug to make the connection to the coil.

The antenna may be adjusted for lowest s.w.r. by either changing the length of the whip or adjusting the spacing of the turns on the coil. When completed, the coil should be given several thin coats of acrylic lacquer (Krylon) to waterproof it.

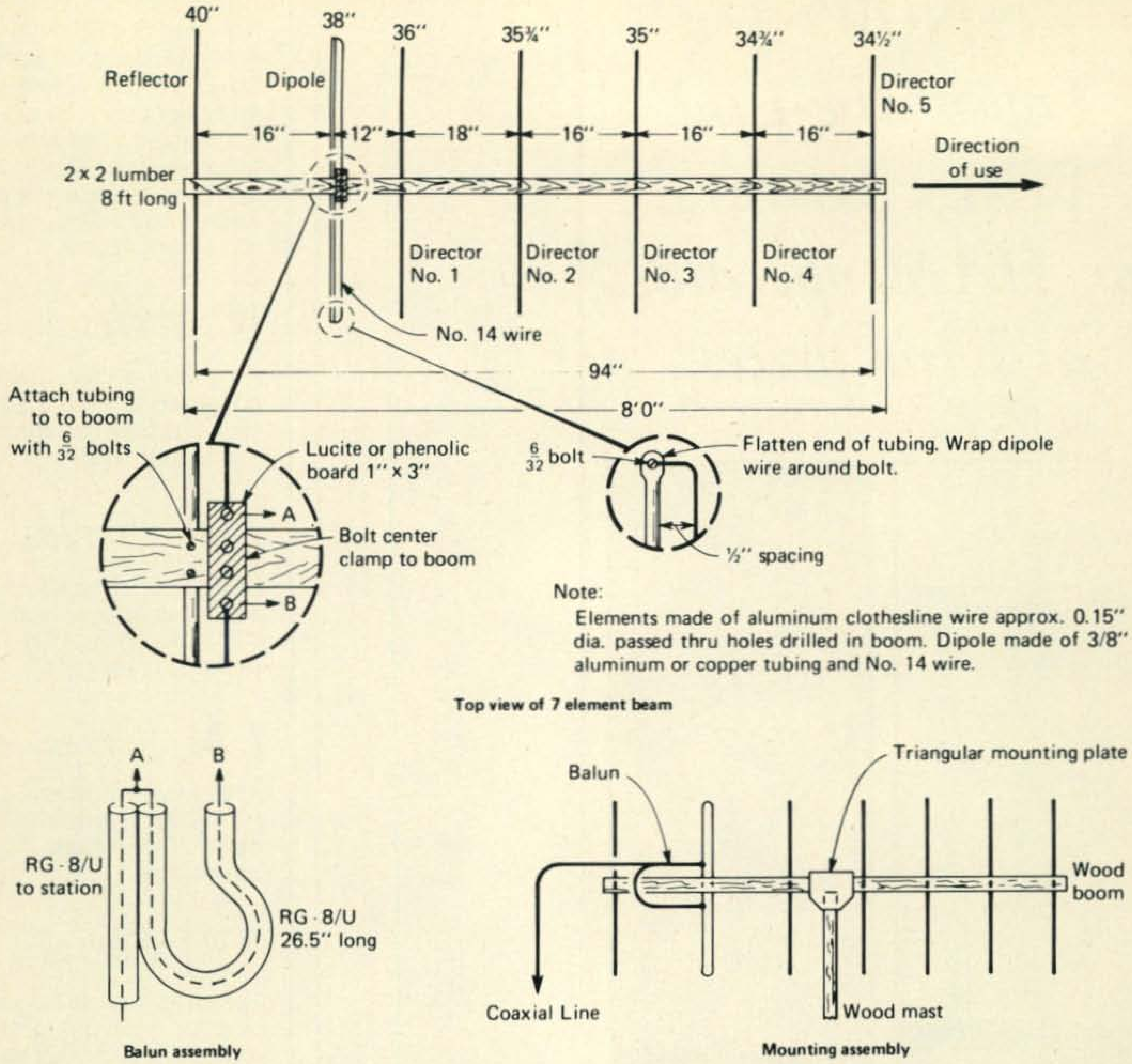


Fig. 2—Seven element beam for 2 meter f.m. provides about 11 decibels power gain over a ground plane. Beam is mounted in vertical plane. Parasitic elements are made of aluminum clothesline wire about 0.15" diameter. Driven element is made of ⅜-inch tubing with a #14 wire used as the matching section. A simple half-wavelength balun is made of coaxial line and transmission line and balun are attached to the folded dipole at points A-B. The beam is mounted to a short wood mast with a triangular, plywood plate and heavy wood screws. The mast, plate and boom are given a protective coat of paint. Elements are left unpainted, as the paint may detune the beam. Coaxial line to station should be kept as short as possible to reduce transmission loss.

"Mercy!!!," said Pendergast. "Have you ever tried 2 meter f.m. with a repeater?" Before I could reply, he continued, "Lotsa more fun than standing in line to work some crazy nut on an island that is submerged at high tide."

He paused, then continued, "I'm a member of the WR6YAK repeater club. Why don't you join up and become a YAKKER?"

"The idea is mind-boggling, to say the least," I replied.

"Let's face it," Pendergast said forcefully, "Ten meters is on the way out, fifteen is pretty bad and soon everybody will be uptight on 20 and 40 meters, six layers deep. That's not for me. I'll get my jollies with this rice box."

I shifted uncomfortably in my chair, and Pendergast continued. "That's why I dropped by. How about some *great* ideas for 2 meter antennas for a newcomer to f.m.? What should I use for the car and for the base station?"

"Why don't you go out and buy an antenna?," I replied uncharitably. Pendergast ignored the thrust. There was a moment's silence, then I sighed deeply. "OK. Let's take the car first. A lot of fellows stick to the

Coaxial Line	Impedance (ohms)	Attenuation (db per 100 feet)						
		3.5 mHz	7.0 mHz	14.0 mHz	21.0 mHz	28.0 mHz	50.0 mHz	144.0 mHz
RG-58/U	53	0.7	1.0	1.5	1.9	2.2	3.1	5.7
RG-59/U	73	0.6	0.9	1.3	1.6	1.8	2.4	4.2
RG-8/U	52	0.3	0.5	0.7	0.8	1.0	1.3	2.5
RG-11/U	75	0.4	0.6	0.8	1.0	1.1	1.6	2.8

Fig. 3—Chart of transmission line loss in h.f. and v.h.f. amateur bands. The loss is expressed in decibels per 100 feet of line, the loss being directly proportional to the line length. Line loss also increases as s.w.r. on line increases.

simple quarter-wave whip mounted at random on the car. This is like washing your feet with your socks on. A much better scheme is to use a 5/8-wavelength whip and mount it near the center of the trunk lid (fig. 1). Field strength measurements have shown that such an installation is about equal to a quarter-wave whip mounted in the center of the roof of the vehicle. The trunk lid installation is a lot easier to work with and you don't run the danger of snapping off the antenna when you pass under tree branches. Then, too, you'll appreciate the ease of installation, especially after you have tried to snake a coaxial line to the center point of the roof of a car."

"The 5/8-wavelength whip uses a base resonating coil, which is simplicity in itself. Adjust it for lowest s.w.r. on the transmission line. Most manufactured 5/8-wavelength whips have fixed coils and are adjusted by trimming the whip length. Either the whip, or the coil, can be adjusted. The adjustment, in fact, is not particularly critical, either."

"Sounds like a good approach," said Pendergast.

"Agreed," I replied. "A good way to start out your mobile operation is with a 5/8-wavelength, extended whip. Mount it on the rear trunk lid. You can buy a clever little mount that clips to the edge of the lid and the antenna is ready to go in 2 minutes."

"Now, for home operation, you can use the same rig, pardon me, rice box, with an a.c. power supply. Since your QTH is in a rather poor v.h.f. location, you may run into trouble breaking the WR6YAK repeater on Mount Pandemonium."

Pendergast looked worried. "I hadn't thought of that," he said, almost to himself. He gazed out of the shack window, his eye following my feedline across the yard and up the side of the garage. He spotted the 2 meter beam atop a short mast at the rear of the garage. "Well," he said, "How about a simple version of your beam?"

"That would do the job for you," I replied. "It's good, cheap and easy to build." I hunted about in the drawer of the operating desk and fished out a drawing (fig. 2).

"Here it is. This inexpensive seven element Yagi beam will put you on 2 meters with a big signal. You can build it for a few dollars and it will provide a power gain of eleven decibels over a ground plane antenna. The beam is mounted with the elements vertical to provide vertical polarization and it's fed with a 50 ohm coaxial line and a simple coaxial balun. The driven element is a folded dipole and you can make the parasitic elements out of aluminum tubing, aluminum wire, or defunct TV antenna parts."

Pendergast peered at the sketch and finally asked, "What's the boom made out of?"

"Wood," I replied. "I used a rug pole that I got for free at a rug cleaning outfit. You can buy 2-inch diameter dowel rod at some large lumber supply houses, or you can use a piece of 2" × 2" square stock. Perhaps even a long broom pole."

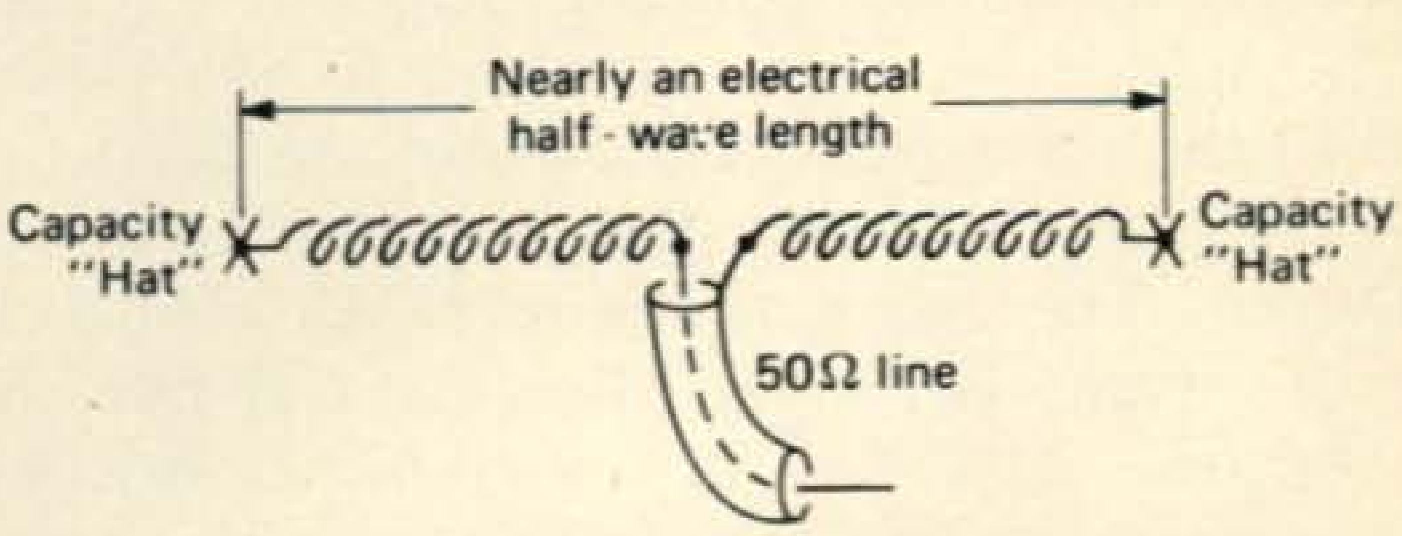


Fig. 4—The compact dipole. An effective, short dipole can be made by helically winding a length of wire and end loading it to resonance. For an electrical half-wavelength, nearly ⅝-wavelength of wire is required in the helix. Antenna is adjusted to frequency by positioning of capacitive hats with respect to the winding of the helix.

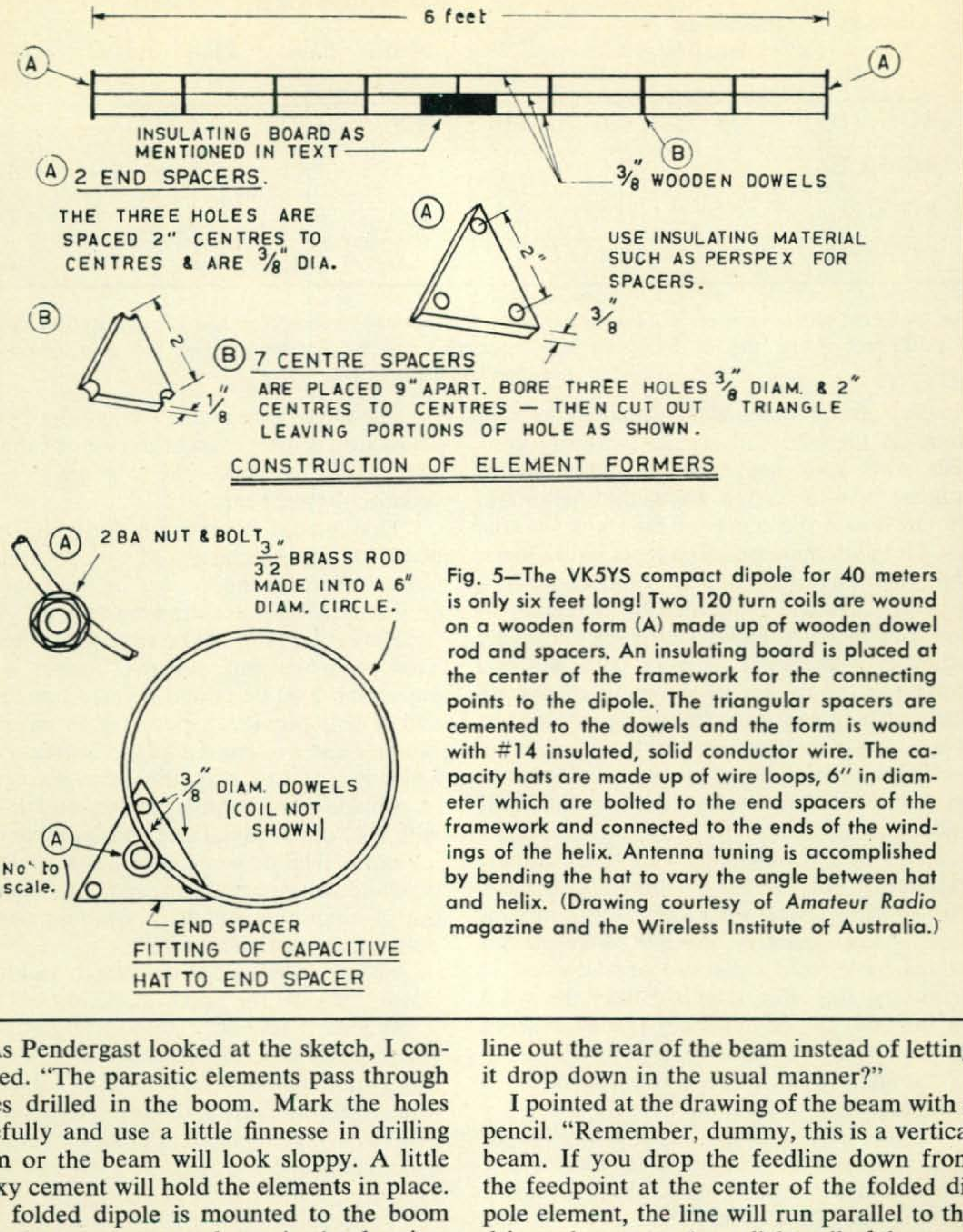


Fig. 5—The VK5YS compact dipole for 40 meters is only six feet long! Two 120 turn coils are wound on a wooden form (A) made up of wooden dowel rod and spacers. An insulating board is placed at the center of the framework for the connecting points to the dipole. The triangular spacers are cemented to the dowels and the form is wound with #14 insulated, solid conductor wire. The capacity hats are made up of wire loops, 6" in diameter which are bolted to the end spacers of the framework and connected to the ends of the windings of the helix. Antenna tuning is accomplished by bending the hat to vary the angle between hat and helix. (Drawing courtesy of *Amateur Radio* magazine and the Wireless Institute of Australia.)

As Pendergast looked at the sketch, I continued. "The parasitic elements pass through holes drilled in the boom. Mark the holes carefully and use a little finnesse in drilling them or the beam will look sloppy. A little epoxy cement will hold the elements in place. The folded dipole is mounted to the boom with the arrangement shown in the drawing. A simple mounting plate is all that is required. The balun is made of an electrical half-wavelength of 50 ohm coaxial line, of the same capability as the transmission line you intend to use. It is folded back along the boom and taped to it."

I paused, and waited for a reaction from my erstwhile 20 meter DX companion. It seemed as if he had passed into a catatonic trance, as he continued to stare at the sketch. Finally, he said, "Why do you bring the feedline out the rear of the beam instead of letting it drop down in the usual manner?"

I pointed at the drawing of the beam with a pencil. "Remember, dummy, this is a vertical beam. If you drop the feedline down from the feedpoint at the center of the folded dipole element, the line will run parallel to the driven element, and parallel to all of the parasitic elements, too. This is an un-good idea and I don't like it at all. It can cause all sorts of unpleasant things to happen. Much better to run the feedline back along the boom and out the rear of the beam. Then you can bring it down *behind* the reflector, as I do." I pointed out the window towards the antenna mounted on the garage.

"Moreover," I continued, "I don't like the

[*Continued on page 73*]

Letters *[from page 8]*

pioneering work. I think the world's DX record (reception only) is held by W8JK, who has made fundamental discoveries in antenna design. One of the radio sources picked up by Dr. John Kraus's Ohio State radio telescope has a redshift (change in wavelength divided by the normal wavelength) of 3.5, which, if taken at face value (you probably can't, but that's a long story in itself) corresponds to a distance of 68,000 million light years!

Modern DXing, which is becoming more and more phone rather than code, is forcing a universal language on us—namely, English. I have talked with hundreds of Japanese hams on the air and I continually marvel at their courage and ability in *communication* in a language so different from their own.

The challenges of today's DXing are greater than ever. The 30 db gain antenna for 10-15-20 meters is still to be built. EME is only in its primitive beginnings as are television, teletype and satellite communications. DXing is far more than just a Numbers Game.

John B. Irwin, K6SE/2
Elizabeth, NJ

It Doesn't Work *[from page 31]*

"It's just a question of using the same equations but putting in differing . . . I mean different . . . values of current gain for each condition. Why didn't I think of that?"

Fred was so excited that he spilt his coffee over the napkin. That broke the spell. It was then that both Fred and Dave looked up to find that to their surprise, all the club members were standing around them and had been following their conversation.

"Say Dave," said Mark, who was also the club president, "what you say is very true. Most of us find that our unit works, do one or two calculations and assume that because our unit works, so will any others. Why I can remember an article years ago in which the author had built a piece of RTTY equipment full of gassy triodes and other such stuff. Lots of people tried to duplicate his design and couldn't get it to work. He had to publish another article a few months later to explain."

"I remember that," said Dave, "but don't blame the magazine. They can't worse-case-analyze all the designs that they publish."

"Worse case what?"

"Worse case analysis," replied Dave. "That's the fancy name for these calculations."

With that the meeting came to a close, the coffee cups were collected up, the ashtrays emptied and the members dispersed into the parking lot.

Fred drove home happily that night, he didn't even turn on his two meter f.m. unit. He was too involved in thinking over his conversation with Dave. His XYL was pleased to see him cheerful again. When she inquired as to the reason, he replied "always do a worst case analysis on both the operating and the non-operating conditions of any circuit."

Of course she didn't understand a single word. ■

Antennas *[from page 46]*

idea of a metal mast getting tangled up with the antenna. So my beam is mounted on a vertical, wood mast about three feet high which is supported by the rotator. That way, there's no vertical metal structures in the immediate field of the antenna."

Pendergast carefully tore the page out of my log book and put the sketch in his pocket. "Thank you, thank you, thank you," he said. "Do you have any more pearls of wisdom to impart to me before I go and help out another fellow amateur?"

"Only one," I replied. "Make sure that you don't lose your 2 meter signals in your feedline. Coax line can be pretty lossy at that frequency, if you have a long run of the stuff Here's a chart of line loss that can help you in this respect, fig. 4). The big stufl has less loss than the small stuff. Remember that."

Pendergast sighed. "Very well." He moved towards the door as if to slip into the night. "One more topic of conversation. I'm on my way over to a new ham in the neighborhood. Just got his General class license. His name is Larry Lovelace."

"Does he have a sister named Linda?," I asked quickly.

"No, said Pendergast," but he does have an antenna problem. Maybe you can give me an idea or two to take along to him."

"Too bad," I replied. "About the sister, I mean. What's Larry's antenna problem?"

"It's the old story," said Pendergast. He lives in an apartment and wants to get on 40 meters. He has the OK to put an antenna on the roof, but it is very, very small. And a 40 meter antenna is very, very big. See the problem?"

"Very clearly. He should move," I replied.

Pendergast shook his head. "No, no. Can't do that. You'll have to come up with a better idea than that."

"Well, the problem's not a new one," I said. "Lot of fellows have been caught in the

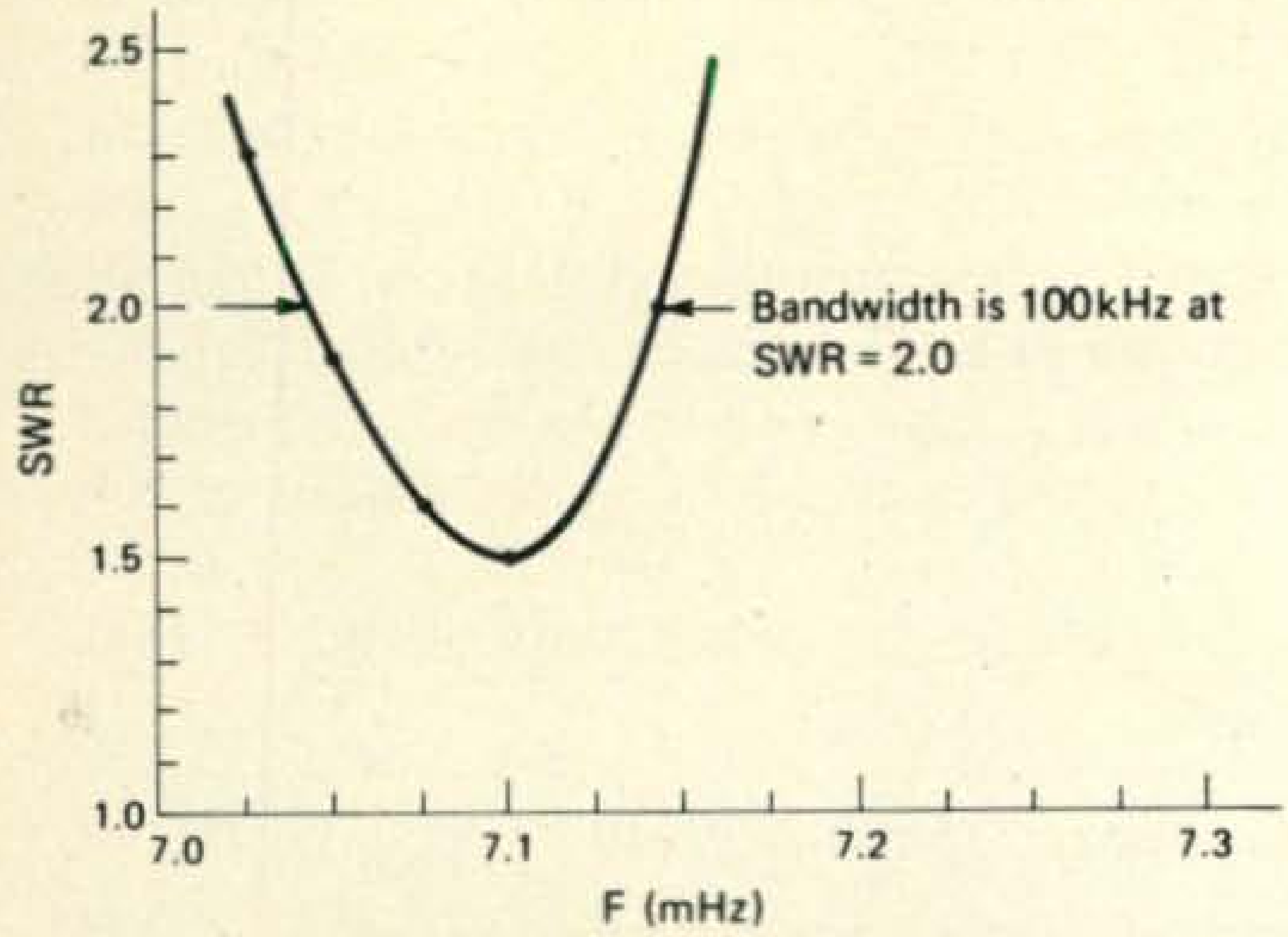


Fig. 6—Helical-wound dipole of VK5YS provides 100 kHz bandwidth between 2:1 s.w.r. points on 40 meter band. This particular model was tuned to 7.1 mHz and could actually be used between 7.0 and 7.15 mHz before s.w.r. value became excessive. For phone operation, the antenna should be tuned to a center frequency of about 7.25 mHz.

same boat. I have a description of a small 40 meter antenna in my file. The original material was in the April, 1972 issue of *Amateur Radio* magazine, which is the excellent publication of the Wireless Institute of Australia. The antenna is a simple version of the compact, helical wound radiator. The idea isn't new, and other articles have described other forms of this antenna. However, VK5YS did a lot of work with his antenna and his ideas seem sound to me (fig. 4). The antenna is simply a 40 meter dipole, wound up into a slim coil about six feet long. Capacitive hats are placed at each end of the assembly to bring it into resonance at the desired frequency in the 40 meter band."

"VK5YS found by experiment that each half of the coiled dipole required about ⅝-wavelength of wire in it. He used #14 insulated house wire, winding it at four turns per inch. Each half of the antenna has 120 turns, making the windings each 30 inches long. Both coils, by the way, are wound in the same direction."

Pendergast, his interest aroused, sat down again and smiled. "This sounds like a great idea," he said. "How did VK5YS mount his coils?"

"Here's a copy of the drawing that was in *Amateur Radio*," I replied (fig. 5). "He made an open, wooden framework out of ⅜-inch diameter dowel rods, six feet long. Triangular spacers were fitted to the ends of the rods (A) and the other spacers (B) were clipped into place along the framework. The whole assembly was firmly glued and given a coat of waterproof epoxy paint. An insulating board was mounted at the center of the framework for the terminals of the dipole."

"Very clever," admitted Pendergast. "I see he made capacitive hats out of loops of heavy copper or brass wire and mounted them to the ends of the antenna framework."

"Right," I replied. "He resonated the antenna to frequency by bending the loops so that the angle to the antenna adjusted the capacitance to the right value. A classic cut-and-try operation. It worked fine, as his s.w.r. curve is very acceptable (fig. 6)."

"I'll pass this information along to Larry," said Pendergast. He got up once again and headed towards the door. As he was about to leave, I asked, "You're sure Larry doesn't have a sister?" ■

SSTV [*from page 40*]

input signal are large enough, the collector voltage will drop while the emitter voltage rises until they meet. Then the transistor will saturate, clipping the negative peaks of the output voltage. (In other circuits you will often use this clipping capability to good advantage.) When designed for maximum output swing and a.c. coupled, the peak-to-peak input voltage can approach $2V_E$ before clipping occurs. Since the voltage gain of the stage is A_V, the peak-to-peak output voltage at the clipping point will be A_V times 2 V_E, when driving a high-Z load.

The remaining steps are fairly straightforward. One thing to keep in mind if the output is a.c. coupled to a load, is that the actual a.c. voltage gain will be something less than A_V. The actual gain value can be calculated by finding the equivalent value of R_C and the load resistance in parallel, and dividing this by R_E. The difference is small if the load resistance is much higher than R_C. (If the load resistance is low, so low for example that it equals R_C, then the gain will be cut in half.)

Let's work out a typical example. Assume that you have an audio signal source of about 2000 ohms impedance and 0.35 volts RMS amplitude. You also have a bandpass filter designed for 600 ohm source and load impedances. You'd like to design an amplifier that will present a high enough impedance to the signal source so as not to load it down, and having sufficient gain to produce a 0.7 volt RMS signal across the 600 ohm load at the output of the filter. An amplifier of the type we've just been discussing looks like a

antennas

BY WILLIAM I. ORR,* W6SAI

"How ya doin', Buddy?" asked Pendergast, as he booted open the shack door and slouched down into the operating chair. With a sigh he planted his feet atop a stack of unanswered QSL cards.

"Reading your fan mail?" he asked.

"Yes," I replied. "These letters have come from readers of my *CQ* column."

"How do they like it?" he asked.

"They love it," I replied. "Did you have any doubt?" Pendergast did not reply, so I continued, "You should read some of the letters. Here's a fellow who wrote me six pages in unintelligible handwriting, wants me to design a complete antenna system for him, and didn't bother to enclose a stamp for return postage."

"I suggest you toss the letter in the circular file," said my friend.

"Here's a really interesting letter. It's from Chris, WBØCXM in Prairie Village, Kansas. He sent me the data on a poor man's Delta Quad that he built for 15 meters. A real dandy design."

Pendergast's feet came down from the desk top with a thump. "A 15 meter Delta Quad?" he asked. "Let me see the letter."

I handed him the letter, and Pendergast read:

"I am enclosing a drawing of an inexpensive 15-meter Delta Loop beam that is easily made, very light and very durable. Other Delta Loops require such massive construction. I made this one on a weekend 2 years ago and it is still going strong.

"Construction details are really simple (fig. 1). Just make it sturdy! I fed it directly with a simple matching transformer, and didn't even use a balun. Guys are attached to a slip ring to allow hand rotation of the whole assembly in a pipe sleeve set in concrete. There's an aluminum plate bearing at the bottom of the hole. It's easy to turn!

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"The crossarms are made of bamboo strung with wire, but they could easily be made out of light, telescoping aluminum tubing, I suspect. Dimensions were taken from the ARRL *Antenna Handbook*.

"I pushed the TV-mast up by myself, but should warn you that the push-up mast I used can slip and come cascading down and might nip your fingertips or the skin between thumb and forefinger! That nearly happened to me. A little care and common sense in erecting the mast is recommended.

"I used this antenna for over 18 months and found out that, although the bottom boom is only about 35 feet off the ground, the antenna was competitive with triband Yagis as high as 70 feet! The s.w.r. ran about 1.5 or less, across the 15 meter band.

"Finally, unlike the square, or diamond-shaped Quad, the metal mast between the elements of the Delta Loop design apparently doesn't interfere with the correct operation of the antenna.

"So far, I've thought of no easy way of mechanically rotating the mast. Some friends have suggested a motor drive with a chain and sprocket. But it is so easy to turn by hand, I just do it that way."

"Very clever," I said. "I'm sending Chris a complementary copy of my new publication, the *Wire Antenna Handbook* for his contribution. I really like his design."

"He might consider giving the bamboo spreader a good coat of spar varnish," said Pendergast. "Or, he could wrap the bamboo with electrical tape between the joints. That helps to lengthen the life of the wood."

"Right," I agreed.

"What else has come in the mail?" asked Pendergast.

"Well, here's a letter from an Australian amateur who unfortunately forgot to sign his name or call. He enclosed a clipping from the *South Australian Wireless Institute Journal* of October, 1972.

The clipping describes a nifty receiving antenna for 160 meters. It is a tuned loop (fig. 2) used for DX tests between VK-land and the USA on the 160 meter band. Basically, the loop is a large, parallel tuned circuit coupled to a low impedance link. The link is attached to the receiver via a coaxial line. The only adjustment that needs to be made is to peak the trimming capacitor for maximum background noise.

"The nice thing about a receiving loop is

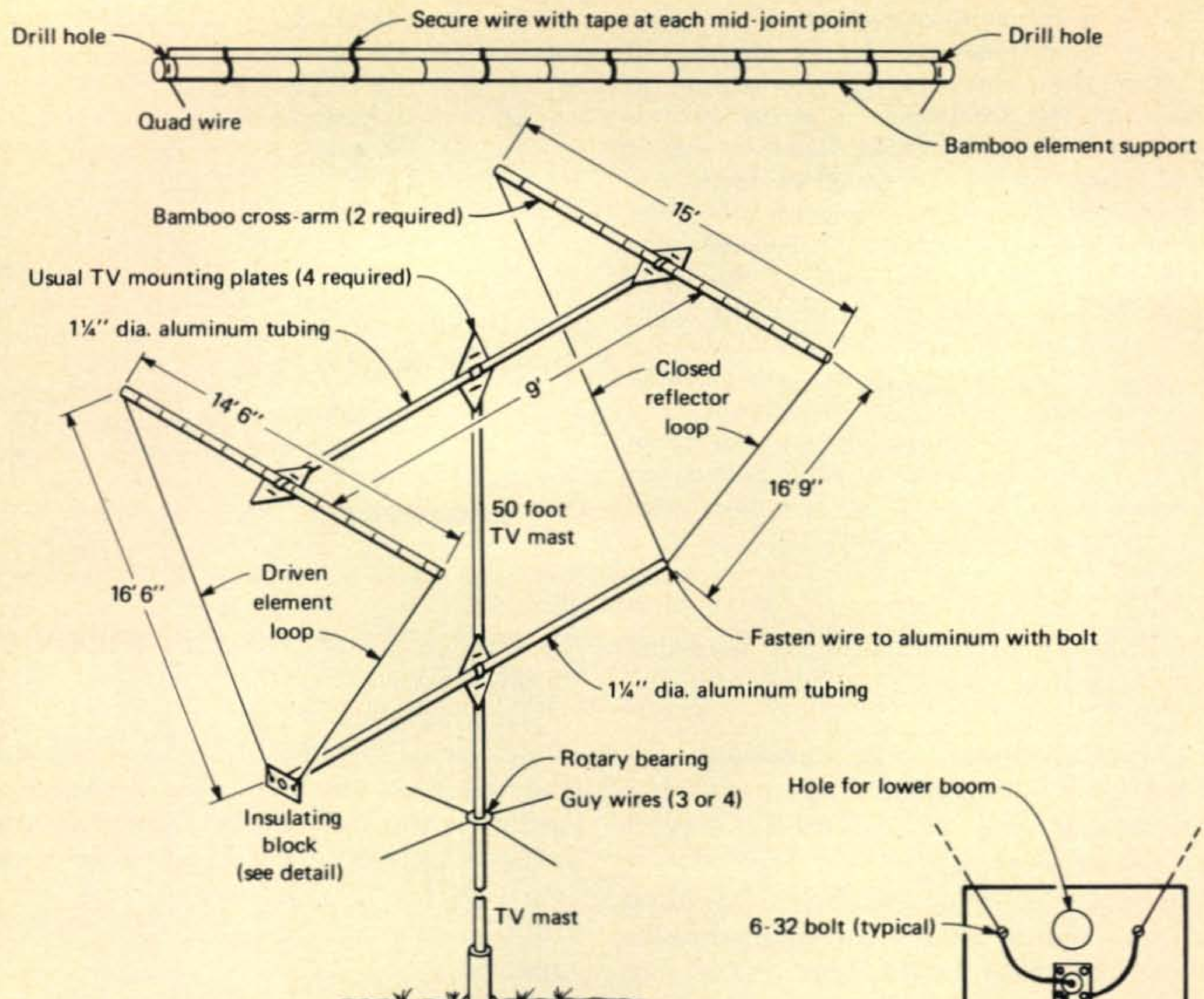


Fig. 1—Detail of the WBØCXM Delta Quad for 15 meters. The two Delta loops are suspended from bamboo cross-arms supported by a 9-foot length of aluminum tubing. The bottom points of the loops are held in position by a second 9-foot aluminum boom. The two booms and the cross-arms are fastened together by means of TV-type mounting plates and U-bolts. The bottom of the closed reflector loop is directly fastened to the aluminum boom with a bolt. The bottom of the driven element is fastened to a phenolic block, insulating the wires from the aluminum boom. The beam is fed with a quarter-wavelength section of 75 ohm line (RG-11/U) which is 7'7" long. The transmission line is RG-8/U. The Delta Quad is supported on a heavy-duty 50 foot TV-style "slip-up" mast held in position with 3 guy wires. A rotary bearing is used so that the mast may be turned by hand. The mast is held in a pipe buried in the ground. A metal plate is placed beneath the pipe to provide a simple bearing for the mast to sit on. The coaxial feedline is brought back along the lower boom and taped to the rotating mast.

that you can null out strong interfering signals. Here on the West Coast, the Pacific Loran chain is very strong at night and often overloads the receiver. The loop helps to knock out the Loran. Unlike smaller loops, this one has plenty of pickup and puts a good signal into the receiver.

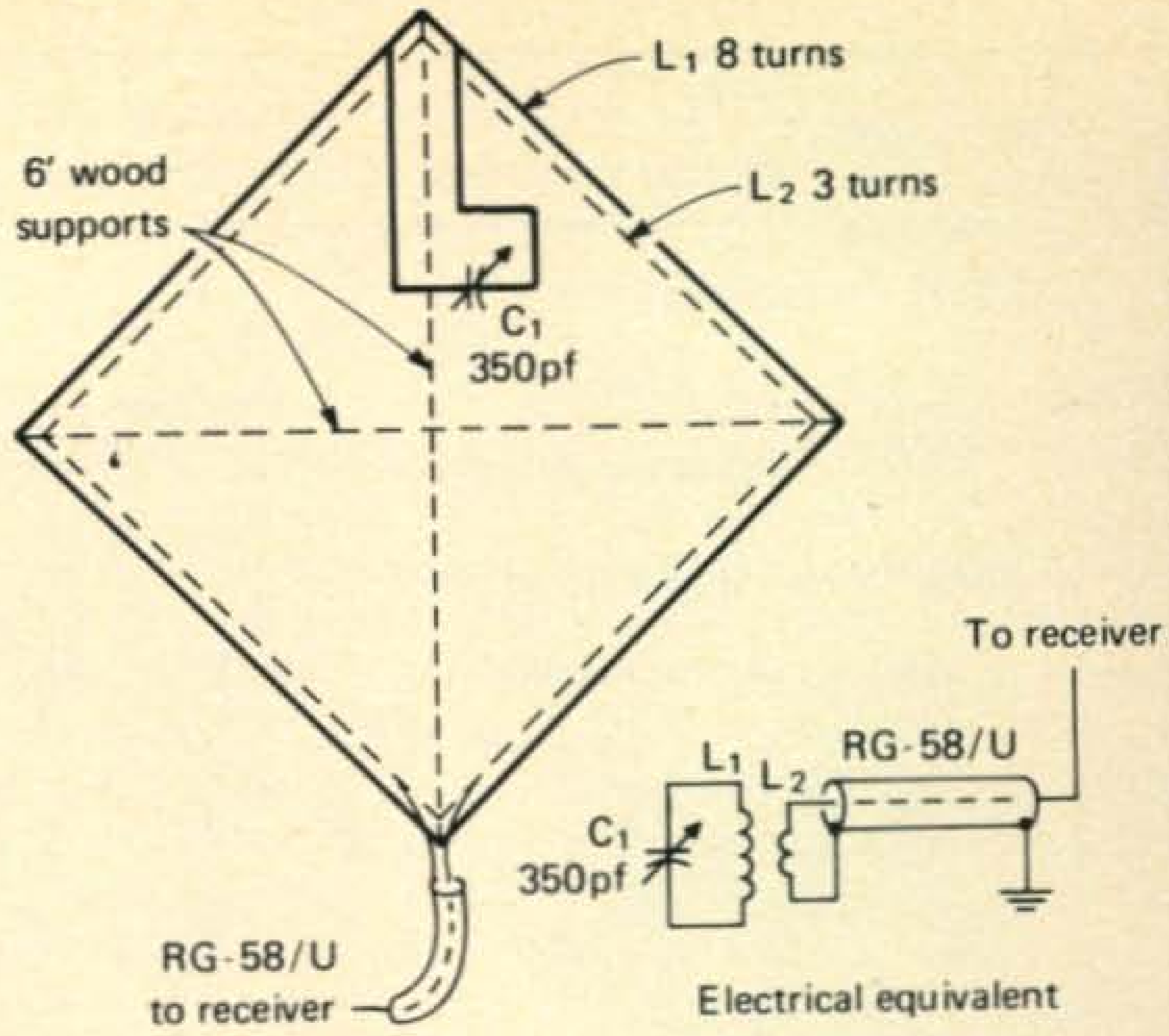
"It is a little too big to go into the operating room, but it is small enough to be turned by a TV rotator, so it could be placed in the backyard, or atop your garage."

"Not bad", said Pendergast. "I just wish I knew who sent you the clipping and who designed the loop!"

"So do I," I replied. "Sometimes the name of the sender is on the envelope and not on the letter. If the two get separated, it is hard to tell who the writer is."

Pendergast picked up the next letter and his face broke into a smile. "Aha," he said. "Here's a letter — and another letter, too — chewing you out for mixing up the drawings

Fig. 2—160 meter receiving loop. The main loop (L_1) is a resonant cicrcuit tuned to either the low or high frequency portion of the 160 meter band. It is link coupled via loop L_2 to the receiver. The framework is made of two 6-foot lengths of lumber held together with a plywood plate at the center. The loops are wound of #20 enamel or insulated wire. Four pieces of wood dowel, about 1" diameter and 6" long are nailed to the ends of the wood frame to provide a surface to wind the loops on and to terminate the ends of the windings. The small broadcast-type tuning capacitor is mounted close to the top of the loop framework in a waterproof box. The 8 turn loop requires about 136 feet of wire. The loop may be peaked on background noise or tuned to resonance with a grid-dip meter.



of the Swiss Quad Beam and the so-called Birdcage beam in your *CQ* column of January, 1974."

Yes," I admitted. "The drawings got switched. I was talking about one antenna, but the illustration was of the other. Several sharp-eyed readers caught that one".

Pendergast frowned, thought a bit, then remarked, "I know what a Swiss Quad looks like, but what's with the Birdcage? Is that like the HB9CV beam? Or is the HB9CV beam the Swiss Quad?"

"Don't get me caught in an international jurisdictional dispute," I replied. "My understanding that the difference between these designs is the feed system. There is a great series of articles in the Japanese ham mazazine *CQ-Ham Radio* covering the so-called HB9CV antenna. Too, bad you don't read Japanese."

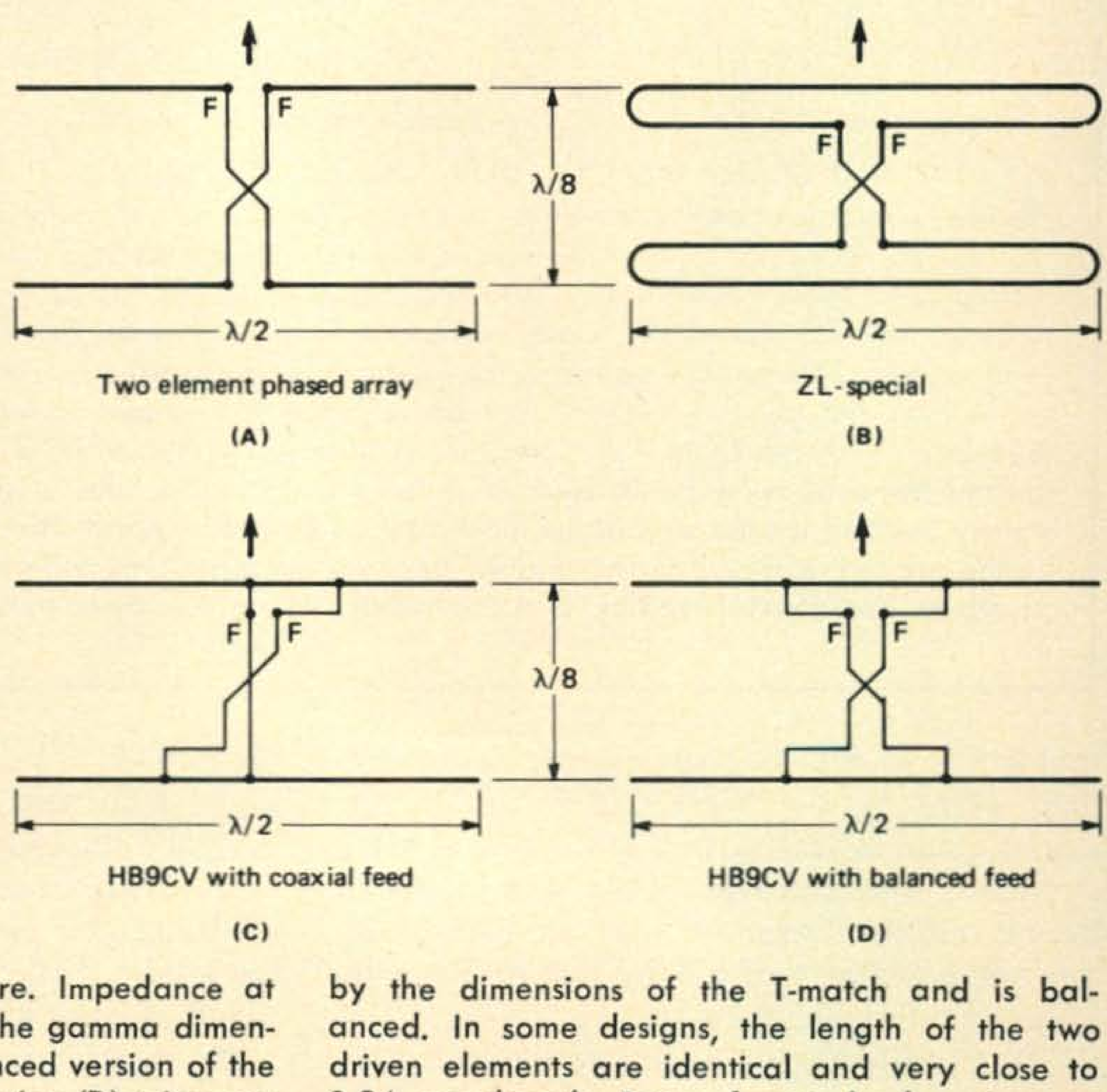


Fig. 3—Various feed systems for a driven array. Basic two element array is shown in illustration (A). This antenna provides about 4 decibels power gain over a dipole with a front-to-back ratio of about 20 decibels. Element spacing is approximately ⅛-wavelength. Impedance at feedpoint F-F is about 104 ohms, balanced. The so-called ZL-Special antenna (B) is similar to the array of (A) except that it is made with folded dipole elements. Impedance at feedpoint F-F is about 420 ohms, balanced. The simple HB9CV configuration is shown in illustration (C). Correct phasing between the elements is obtained by interconnecting two gamma matching systems with a phasing wire. Impedance at feedpoint F-F is determined by the gamma dimensions and is unbalanced A balanced version of the HB9CV system is shown in illustration (D) using two T-match systems, interconnected with a two-wire line. Impedance at feedpoint F-F is determined by the dimensions of the T-match and is balanced. In some designs, the length of the two driven elements are identical and very close to 0.94 wavelength. Better front-to-back ratio may be obtained by making the rear element slightly longer than the forward element.

I took a magazine the size of a telephone directory down from the shelf. Pendergast whistled when he saw it. "Wow! A color cover, over 500 pages and a summary of the contents in English, written by W9PQN/JA1YSH!" He leafed through it quickly. "Even if you don't read Japanese you can get a lot of it from the drawings and photos. And look at all that Japanese ham equipment!" Pendergast's eyes glowed.

"And they have a simple description of the ZL-beam and the HB9CV beam (fig. 3). As you can see, the difference is in the feed system. The HB9CV scheme can be used with either a balanced or unbalanced feed system. Actually, it is a version of the gamma match or the delta match applied to a driven array."

"Then these feed system would work equally with either a Yagi or a Quad," asked Pendergast.

"Right", I replied. "Speaking of Quads, I met Clarence Moore, W9LZX, in Houston, at the *National Association of Broadcasters* and he described the great results he was having from his special 80 meter Quad."

"80 meter Quad," gasped Pendergast. "What does he attach it to?"

"Well, it is a little different than what you are visualizing," I replied. "Actually, it is an antenna designed for maximum signal strength close-in, rather than for DX contacts. The antenna is a driven Quad loop, mounted parallel to the earth's surface. It squirts the radio signal straight up to the ionosphere, which reflects the maximum signal down within, say, a 500 mile radius. So the antenna produces a tremendous signal within a couple of hundred miles. W9LZX says a ground screen under the antenna helps, but that it still works well without it (fig. 4)."

"I like that," said Pendergast. "The W9LZX Lazy Quad loop should be great for local nets and rag-chewing. Besides, it doesn't take up much space and can fit into a back yard. And it doesn't have to be very high in the air." Mind if I make a copy of this?"

"Go right ahead," I replied.

"Well, thank you," said Pendergast, arising and stuffing his pockets with bits and pieces of paper, "I just bought a large notebook, and I am going to paste all this information in it. And I'm also going to keep records of all the antennas I put up, along with s.w.r. curves, and all that good stuff."

"That's a great idea," I said. "I do it here, because it is very easy to forget this year what you did last year. Permanent records are very helpful. About 2 year ago I put up a tribander and carefully measured the s.w.r. for each band. About every six months I recheck my measurements, and I've found that the antenna traps age. That is, they change with time, and the s.w.r. curve of the antenna gradually shifts as time goes on. The s.w.r. curves I run now don't look at all like the curves I ran when the beam was brand-new."

"Well, what's happening to the antenna?" demanded Pendergast.

"I wish I knew," I replied. "It still works good. But one of these days I am going to have to take it down and examine the traps. I think it is just Mother Nature at work. That is, the continual force of gravity plus the forces induced by the wind may possibly cause cold flow in the forms that support the trap coils. That's my guess."

Pendergast prepared to leave. "A most informative session," he declared. "See you on the low end one of these days." ■

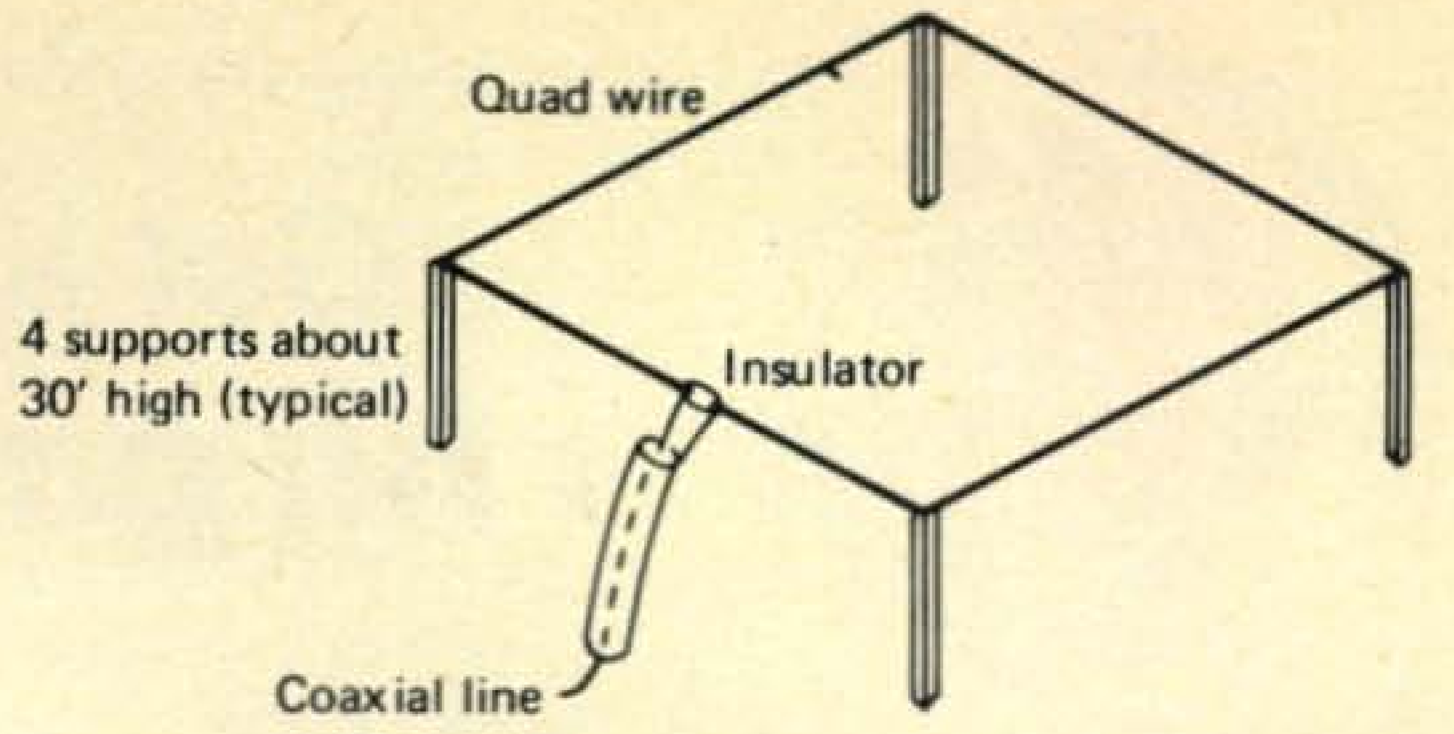
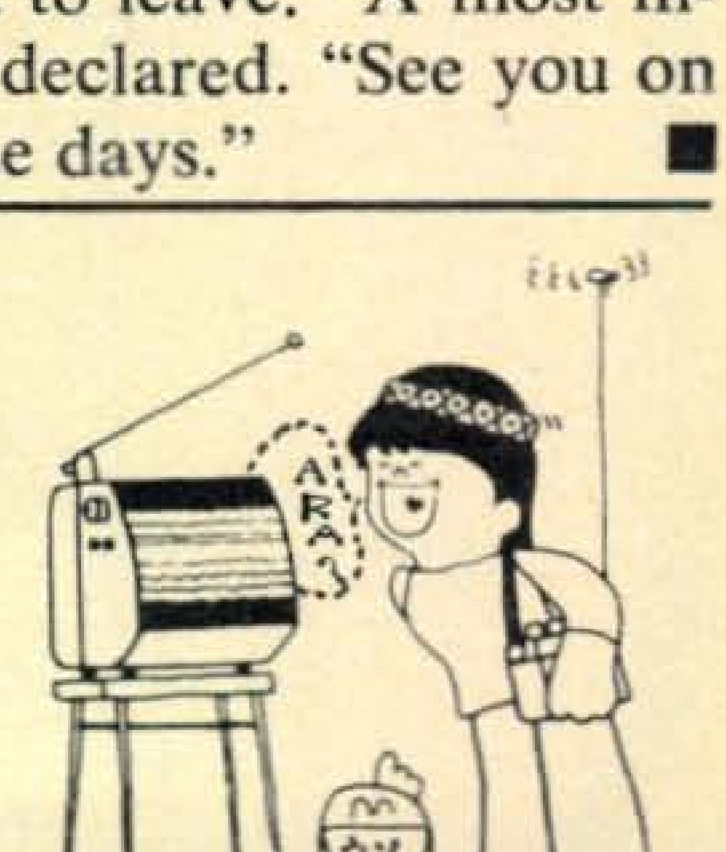


Fig. 4—The W9LZX Lazy-Quad loop antenna for 80 meters. The antenna consists of a single turn Quad loop mounted parallel to the surface of the ground. The loop is 67′ on a side and is supported about 30 feet above ground (the height is not critical). Antenna is broken at midpoint of one side and fed with a 50 ohm coaxial transmission line. Since there is no polarization, in the common sense of the word, the loop may be broken at any point for the feedline. It may be more convenient to break it at one of the supporting points and run the feedline down the support structure. Maximum radiation from antenna is at very high angle to lay down a good signal at distances less than 1000 miles on the 80 meter band.

Mako

. . . by JA3OVM



TVI

antennas

BY WILLIAM I. ORR,* W6SAI

IT's a lot of fun to read about five element Quad beams for 20 meter DX work, 3 element Yagis for 40 meters or foxy 80 meter monster Quads on 120 foot towers, but let's face it . . . "modern living" has its drawbacks as well as its blessings. Many amateurs have discovered, to their chagrin, that a large percentage of new homes, condominium apartments and townhouses in the larger cities have iron-clad restrictions against the erection of *any* antenna written into the lease or deed. To cap it off, the widespread use of cable TV in such dwellings, plus the installation of underground utility wires makes the amateur antenna an all-too-conspicuous standout and eyesore to many persons.

In some instances, the erection of a small antenna is tolerated, but the amateur immediately becomes the unwilling target for various complaints of television and stereo interference from suspicious neighbors, often before he even gets on the air!

Lack of available space, onerous restrictions and esthetic considerations can thus inhibit an otherwise enthusiastic amateur and reduce him to the ignomy of working through the local 2 meter repeater with a "rice box" and a 19-inch whip antenna in his living room. Antenna woes can be many, but with ingenuity and tact, many amateurs may erect an unobtrusive antenna without running afoul of the neighbors, the hard-hearted landlord or the steely-eyed Building Inspector.

The $64 Question

During the short life of this column, one of the most-asked questions dealt with the problems of erecting some kind of high frequency transmitting antenna under restrictive conditions: not enough room in the yard, landlord problems, deed restrictions, telephone and utility wires in the way and similar perplexing hazards. Unfortunately, no universal problem-solving antenna is at hand and each antenna installation must be solved on its own merits. Antenna information in the various handbooks is all well and good, but the pretty pictures of antennas atop sky-high poles, or stretched tastefully across a broad expanse of grass usually don't bear any relationship to the real-life situation in a large city where the amateur is surrounded by neighbors and buildings[1].

The problem, then, is how does the amateur —forced to operate under such restrictions— get on the air and put out a respectable signal on the DX bands? This column will be devoted to this difficult problem.

Provided there are no legal obstacles, which are outside the scope of the present discussion, it is possible to make the best of a delicate situation by following the principle of the "invisible antenna". This practical concept works on the theory that if the antenna is not easily seen, or recognized, it will not be an antagonistic object to the observer. In many hardship cases, it is possible for an amateur to get on the air with an "invisible" antenna and enjoy rag-chewing and DX on the high frequency bands without anyone being the wiser. Needless to say, this theory is valid only if the transmitting gear is fully TVI- and stereo-proof!

The "Invisible Antenna" Concept

The "invisible antenna" concept is based upon the fact that the antenna in question is either *hidden from view,* is *visible but disguised,* or it *disappears from view* when not in use ("when the sun goes down, the antenna goes up", as one wag put it). One of these styles of antenna can allow an amateur to get on the air under circumstances that would normally prohibit a more orthodox installation. The "invisible" antenna is not a touch of magic; it works according to accepted antenna theory and, when properly adjusted, can provide many happy on-the-air hours, regardless of the jaundiced eye of the next door neighbor.

The Indoor Antenna

The first type of "invisible" antenna to consider is the *indoor antenna.* A great majority of small dwellings and apartment houses in the United States and Canada are of wood frame construction with a roof of composition material or wood shingles. The only metal in the building (aside from nails) is the electric wiring, the water pipes and the drain lines. In recent construction, moreover, the drain lines—instead of being made of iron pipe—are made of large-diameter plastic (polyvinyl chloride) pipe. Experience has shown that a wood building causes little or no effect on an antenna placed within it, provided some care is taken not to let the antenna couple itself electrically with the wiring and metalic plumbing system of the building. Thus, standard dipoles and end-fed single

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[1]An outstanding exception to this comment is W6SAI's new Handbook, *Simple, Low-Cost Wire Antennas* (Radio Publications, Inc., Wilton, Conn. $3.95 plus 25c postage and handling). Highly recommended for beginner and old-timer alike. It has plenty of information on "invisible" antennas for "tough" locations.
—*Editor*

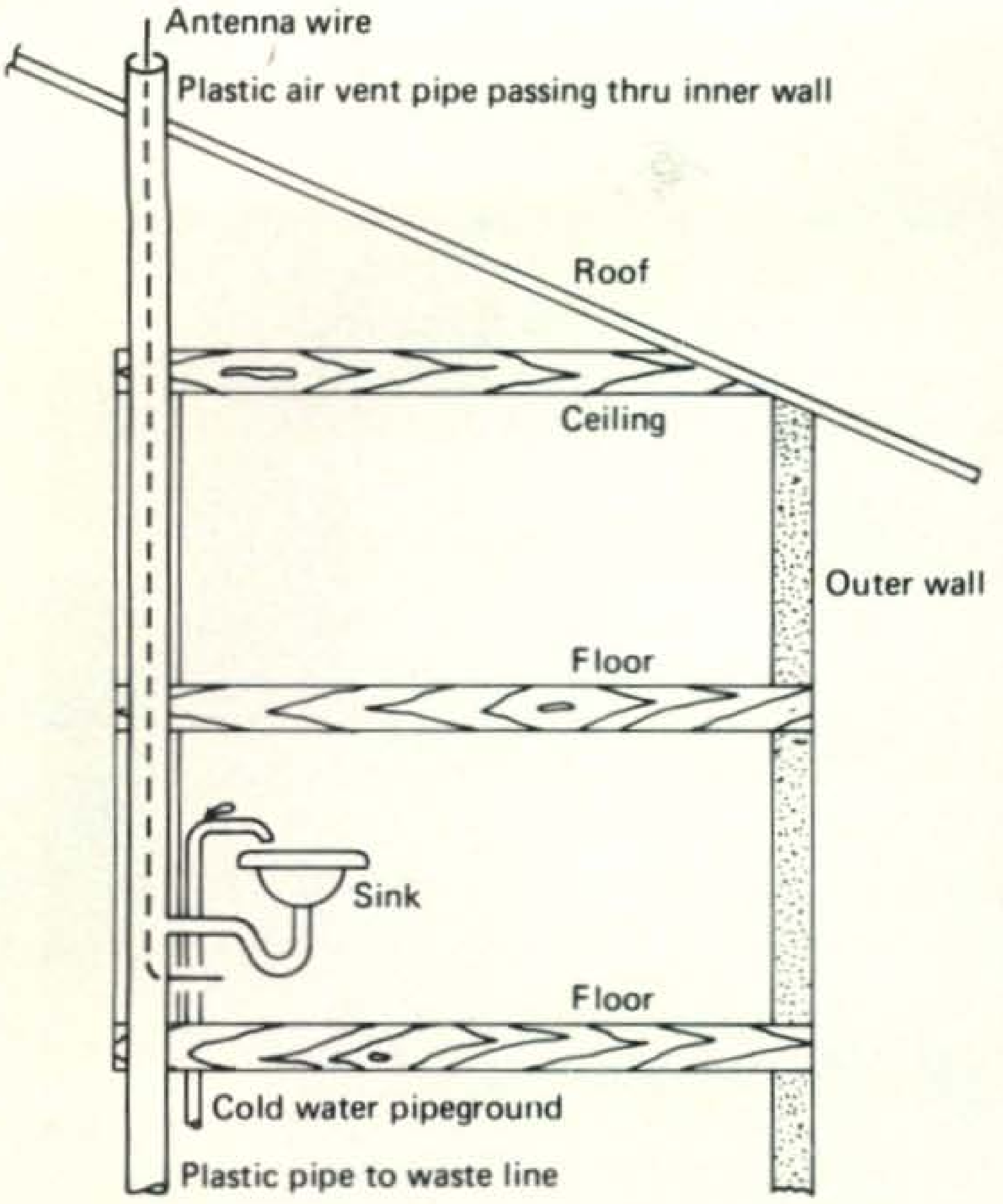

Fig. 1—"Invisible" vertical antenna is run from ground floor apartment to roof through plastic vent pipe of bathroom sink. Copper water pipe at sink serves as a convenient ground connection.

wire antennas can be erected within such buildings with an excellent chance that they will work as well as in open air.

The indor antenna is height-limited by the ceiling or roof line of your dwelling, so if you contemplate such an antenna, it is much better to place it on an upper ffoor of a building than on the ground floor. If you are lucky enough to have an attic space, or loft, the antenna should be strung up near the roof, provided it is not metal.

If you have access to the roof, an antenna may be laid directly on the surface of the roof, or perhaps strung a few inches above the roof, using existing vent pipes or chimneys for tie-points. If the antenna is placed indoors, it should be erected at right angles to most of the electric wires hidden in the walls of the building. By examining the plugs and wall switches, it is often possible to make a good guess as to the actual position of the wiring in the walls. The antenna can slope a bit, or be bent, if necessary, to fit into the available space. The whole operation, while not complicated, is cut-and-try and it is easy to move the antenna about to determine the best placement. Once the location has been chosen, the antenna is held in place using heavy twine (no insulators are needed) and hook-eyes placed in appropriate spots in the walls and ceilings.

If the amateur staiton is on the ground floor, the situation is more difficult, but still not impossible. It may be practical to run a coaxial line to an attic area, or loft; or possibly up a wiring duct to the roof. One enterprising amateur found that the air vent pipes in his plumbing system that ran up to the roof, past two apartment levels, were made of plastic pipe. He drilled a small hole in the vent pipe, well above the water level and fished a wire down the vent pipe from the roof, pulling the end out in his apartment! This gave him a 28-foot high vertical antenna that ran from the wash basin in the bathroom up to the top of the vent pipe on his roof! The adjacent cold water pipe was used for a ground connection. See fig. 1.

The All-Important Ground Connection

Many amateurs have run into difficulty with indoor antenna systems— particularly the end-fed antenna-plus-tuner combination — because they have a poor ground connection, which can cause improper transmitter loading, result in TVI and destroy the efficiency of the antenna.

Experience has shown that a rod driven into the soil or a wire connected to a radiator or heating vent is a poor radio ground. To make matters worse, the longer the wire connection between the transmitter and the ground, the poorer is the electrical efficiency of the ground. To put it bluntly, most typical ground connections are worthless, especially on the higher frequency amateur bands, where the length of the ground lead is an appreciable fraction of a radio wavelength. A sure sign of a poor ground is r.f. on the microphone that "bites" the operator whenever he touches it. Feedback and instability of the equipment are also signs of a poor ground connection.

These problems multiply when an indoor antenna is used, as the transmitting equipment is usually in the strong, nearby field of the antenna. Thus, regardless of the type of indoor antenna used, dipole, end-fed, or whatever, the *first secret of successful operation is a good ground connection!*

Broadcast stations have extensive ground systems that cover an area the size of a city block, but such an elaborate installation is impractical for radio amateurs in apartment houses and condominiums and they must settle for something less. Fortunately, this can be done by the use of a *tuned radial ground wire,* which is a modification of a more complicated grounding technique used in many commercial installations.

The Tuned Radial Ground Wire

The term "radio ground" does not necessarily imply a direct connection to earth, but rather an r.f. return path to the portion of the equipment normally accepted as being at ground potential. The equipment may, or may not, be connected to an actual earth ground. A few ready-made ground systems exist in some homes and, if available, should be used in conjunction with the tuned radial ground wire. For example, the cold water distribution system in

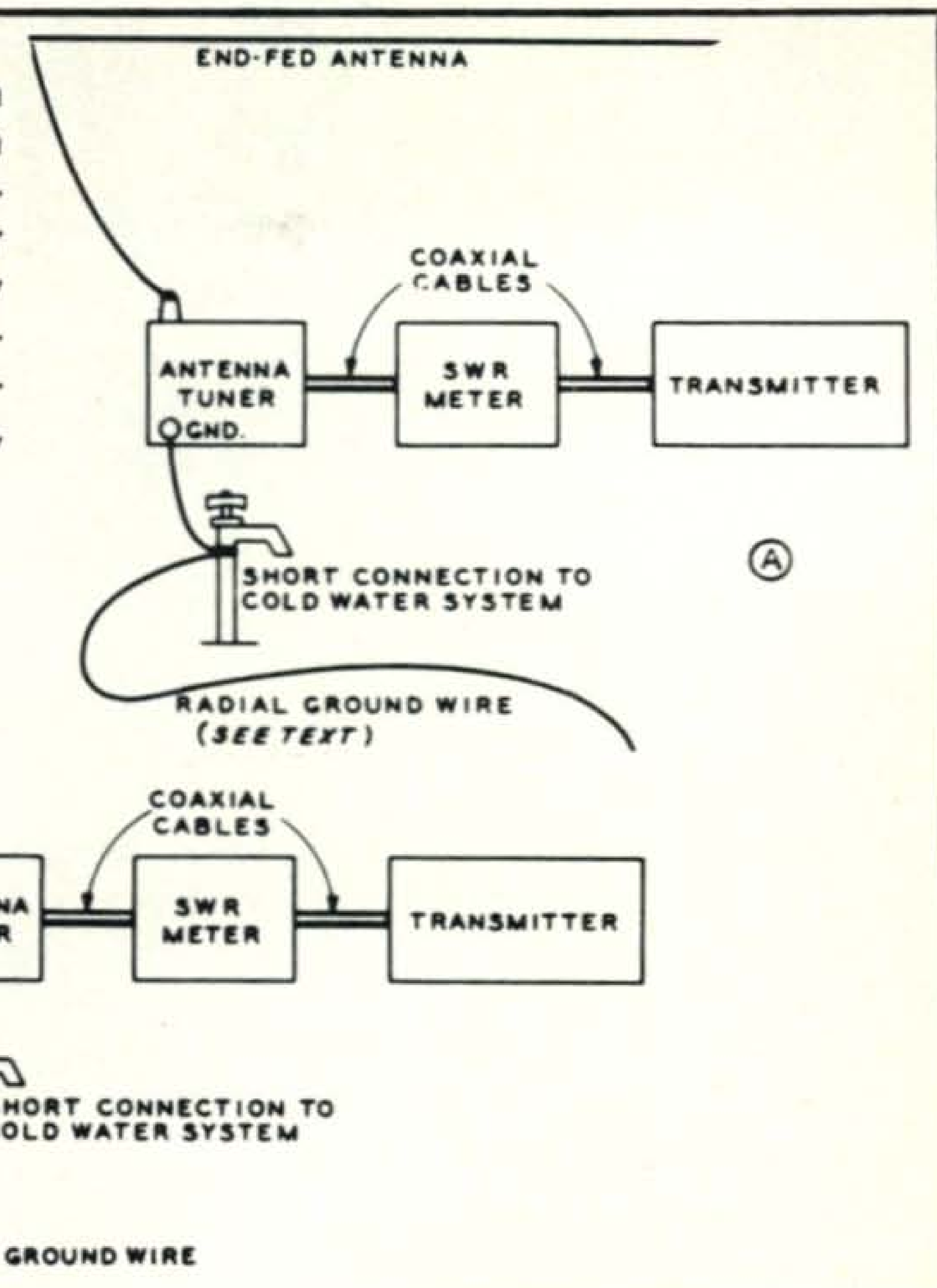

Fig. 2—The tuned radial ground system used with an end-fed antenna. (A)—Single band operation with one radial ground wire. (B)—Two band operation using two radial wires. If a dipole or other balanced antenna is used, the antenna tuner may be omitted. Each radial ground wire is one-quater wavelength long at the operating frequency. (Drawing courtesy of Radio Publications, Inc.)

many buildings is composed of copper pipe, soldered at the joints and grounded at irregular intervals. This can serve as an auxiliary ground in conjunction with the radial wire. Water systems of iron pipe have questionable joints (as far as electrical conductivity goes) and plastic water pipe systems are useless as a radio ground. An underground sprinkling system composed of copper pipe is an ideal auxiliary ground, provided the connecting lead from pipe to equipment is short and direct—not more than a few feet long.

The tuned radial ground wire (sometimes called a counterpoise by Old Timers) is an artificial electric ground that is very effective. It is simply an insulated wire, one-quarter wavelength long at the operating frequency, connected to the chassis of the transmitter at one end and run away from the equipment in a random direction, either indoors or outdoors. The far end of the wire is left free and is taped to prevent accidental contact. The wire is "hot" with r.f. energy at the open end and can cause a nasty r.f. burn to anyone unfortunate enough to touch it when the transmitter is operating.

As the tuned radial ground wire is resonant, it will only work properly on one amateur band. Two or more radial wires may be attached to the transmitter for multi-band operation, if a multi-band antenna is used (fig. 2). Radial placement is not critical, although it is usually run in a horizontal plane, along the floor of the radio room tacked against the wall, or perhaps out the window and along the side of the dwelling. For the lower frequency bands, where the radial is quite long, it can be run out of the window, down to ground level and passed through bushes or trees, a few inches above the ground. It should not actually touch the ground, nor any metallic objects that will detune it. It is not considered to be an antenna, so it does not have to be "in the clear", but it should run in as straight a line as possible.

If a reasonably good ground connection is at hand, it should be used along with the radial ground wire. The combination of the best possible radio ground, plus a radial wire, "tames" the most difficult antenna and reduces loading problems to a minimum. A chart of radial wire lengths for the h.f. amateur bands is given in fig. 3.

Bury Your Radial Wire?

Placing a tuned radial wire about your dwelling may be a real problem unless the wire

[*Continued on page 84*]

Band	Radial ground wire length
160 low	123′ 0″
160 high	120′ 0″
80	63′ 0″
40	32′ 6″
20	16′ 6″
15	11′ 0″
10	8′ 3″

Fig. 3—Radial ground wire length.

QRP [*from page 25*]

LP2000 Monolithic IC transmitter, Plessey SL610 & SL611C low-noise r.f./i.f. IC's, SL620, SL621 a.g.c. IC's, SL640, SL641 Double-Balanced Modulator IC's, SL630 audio IC; plus Fairchild voltage regs., National LM370 a.g.c. IC, Motorola MC4044P phase detector IC—I've got to stop here—it goes on and on!

Building the Junk-Box

B&F Electronics, 119 Foster St., Peabody, MAS 01960. Good on many IC's, and a lot of way-out stuff. These guys got their start in hamfest fleamarkets and stock accordingly. Bargains. *TriTek, Inc.,* P.O. Box 14206, Phoenix, AZ 85031: another flea-market oriented outfit often with just the item you need most. Special in latest flyer—5% precision carbon-film resistors, regular values, ¼ and ½ watt sizes—10¢ each, or 10 of one value for 50¢. IC's, transistors, but sporadic supply. *S&R Enterprises,* 1344 E. Indian School Rd., Phoenix, AZ 85014, was the first to bring new balanced emitter power r.f. transistors to the general public, and continues to produce amazing bargains on MARKED (never accept unmarked!) r.f. power devices: 2N5589—$2.00, 2N5590—$6.50, 2N5591—$7.50! (5, 10 and 25 watts min. output respectively). Also bargains on good transistors like 2N3866 (10 for $4.50) and others.

Well, that's the list. One of the big houses, plus Circuit Specialists, plus S&R's power transistor line, and most projects will be handled completely. I've had good luck with each of the outfits listed above, so I can recommend them. Hope this helps out a bit. We'll dip into the mailbag next month. Remember, August 20 is deadline for submissions for *The Milliwatt Field Day Trophy*—a copy of your ARRL "check sheet" plus description of your equipment and operating location.

73, Ade, K8EEG

Antennas [*from page 49*]

can be tacked to a wall, or run through a flower bed. In the open, the wire is quite visible and creates a potential hazard to people walking about since it is possible to trip over the wire if it is low, or run into it if it is higher. The temptation exists to bury the wire, but this should not be done, as the wire is really part of the antenna system and is tuned to your operating band. Burying the radial would detune it, and it simply would not do the job. A ground system can be made of buried wires, but that's a different story.

Outdoor Antennas?

The next column will deal with "invisible" and "disappearing" antennas for outdoor use in difficult locations.

73, Bill, W6SAI

antennas

BY WILLIAM I. ORR,* W6SAI

LAST month's column discussed antenna problems some amateurs encounter in the form of restrictions and regulations written into leases and deeds. Some homes, condominium apartments and townhouses frown on the erection of any antenna, and may even have restrictive clauses incorporated into lease or deed. In addition, the widespread use of cable TV, plus the installation of underground utilities, makes the ham antenna an all-too-conspicuous eyesore to the unsympathetic neighbor or landlord.

Provided there are no legal obstacles, which are outside the scope of this column, it is possible for the enterprising amateur to get on the air by using an "invisible antenna," which is either hidden from view, visible but disguised, or which disappears from view when not in use. The indoor antenna was discussed last month, and this column will cover some other antenna projects for "tough" locations. An "oldie but goodie" is the so-called "Pole Lamp antenna."

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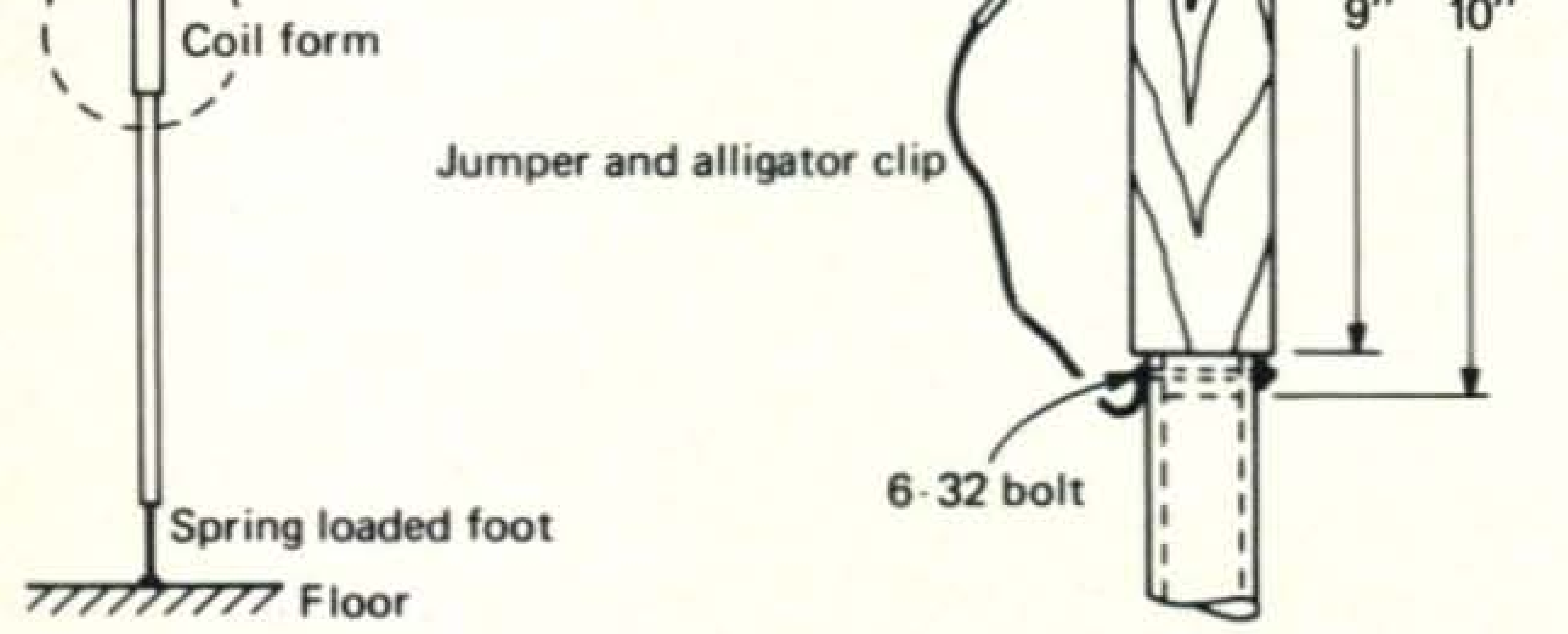
The Pole Lamp Antenna

Sometimes the situation is desperate. An amateur rig can be squeezed into a closet cr bookcase, but what about the antenna? If limited to indoors, can the antenna be blended in with the decor of the room and not be an eyesore? The answer to these questions is "yes" when a pole lamp antenna is used.

The pole lamp antenna, fig. 1 is a decor-matching accessory to the home if carefully built. This unique antenna is made from a spring-loaded pole lamp structure, which is placed in position between floor and ceiling of the radio room. Many home furnishing stores carry a variety of pole lamps and decorator poles which can be used to support shelves, radios, books and other objects. Plain, unadorned poles and the various pieces which go together to make up the poles can be purchased. The most popular and least expensive decorator pole is a three-section assembly about seven feet long having spring-loaded "feet" in the ends which are wedged against ceiling and floor.

If you are fortunate, a pole may be purchased with a wood center section, which is required for this antenna assembly. If only an all-metal pole is obtainable, the center section must be cut in half and trimmed for insertion of a wooden plug to serve as an insulator and support for the center tuning coil.

The spring-loaded pole antenna is operated in a vertical position, with a high-Q, tapped tuning coil placed at the center. The coil resonates the compact antenna (which is a first cousin of the popular mobile whip antenna) to the band in use and the antenna, plus the length of wire connecting it to the transmitter,



Band	Center coil
80	90 turns no. 16 tinned wire, 2½" dia., 9" long
40	Tap for approx. 28 turns in circuit
20	Tap for approx. 15 turns in circuit
15	Tap for approx. 8 turns in circuit
10	Short out coil

NOTE:

1. Connect loading coil between 6-32 bolts.
2. Turn down ends of plug to fit within pole. Epoxy joint.

Fig. 1—Decorator pole antenna serves as a good, indoor multiband antenna system. Pole is cut in half and insulating plug inserted to provide mounting area for resonating coil which connects the antenna halves. Pole antenna is used with radial ground wire for best results. (Drawing courtesy of Radio Publications, Inc.)

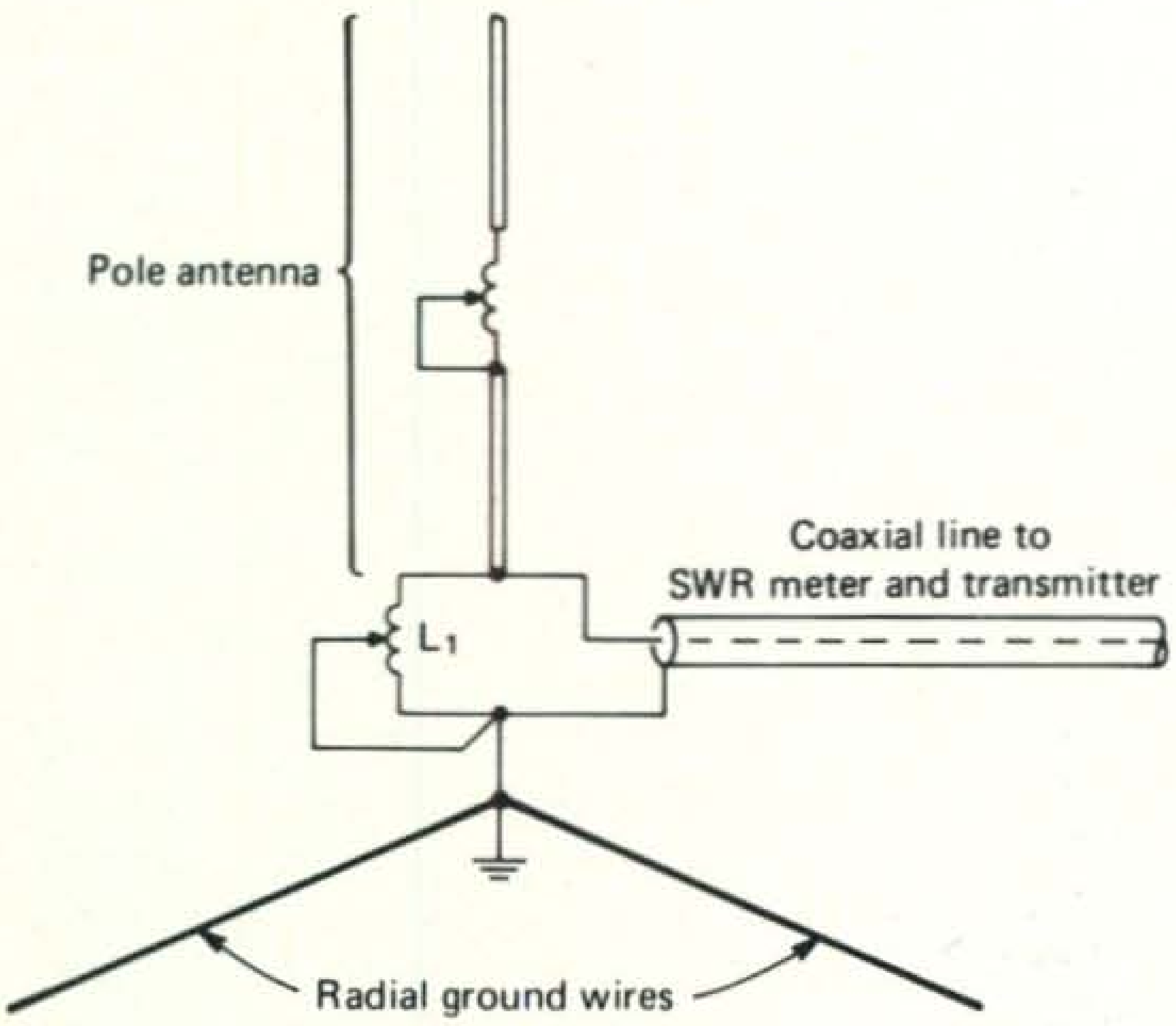


Fig. 2—Pole antenna is fed with coaxial line from SWR meter and transmitter. Coil L_1 is a matching device for 40 and 80 meters, as whip has very low radiation resistance on those bands. The coil is 6 turns #12 wire on a 2" form, wound to a length of 2 ".

are operated in conjunction with a tuned radial ground wire, if convenient, or with a cold water plumbing system ground.

Tuning the Pole Antenna

The approximate number of turns on the center coil for each h.f. amateur band is given in the illustration. An s.w.r. meter is used to tune up the system. With the transmitter working on very low power, the number of turns in the loading coil are adjusted for the lowest value of s.w.r. on the transmission line. Turns are adjusted one at a time.

The antenna, being short, is quite frequency sensitive and any major shift in frequency (especially on the 80 meter band) requires a readjustment of the coil tap for best performance. Antenna loading on 80 and 40 meters may be facilitated by placing a small adjustable coil (L_1) across the coaxial line, right at the base of the antenna. This coil, plus the loading coil, are adjusted together for lowest value of s.w.r. on the feedline, as shown in fig. 2.

A tuned radial wire, such as described in last month's column is used with the pole lamp an-

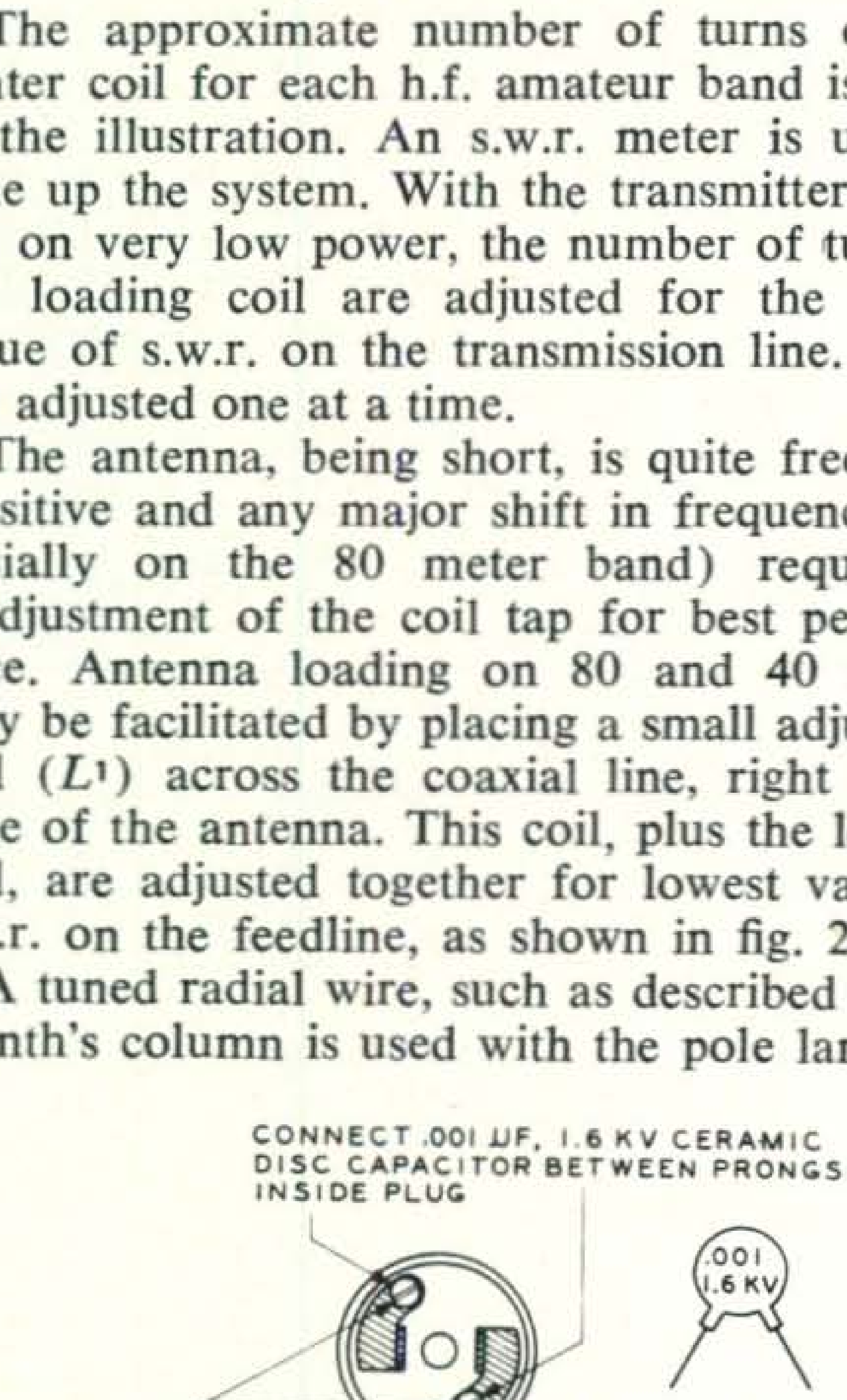


Fig. 3—Disc capacitor placed in spare line plug can be used to "de-TVI" the electrical wiring of your building. (Drawing courtesy of Radio Publications, Inc.)

tenna. This is an artificial ground system that is very effective. Quite simply, it is an insulated wire, one-quarter wavelength long at the operating frequency, connected to the ground post of the transmitter at one end and run away from the equipment, either indoors or outdoors. The far end of the wire is left free and taped to prevent accidental contact. Radial placement is not critical and it may be run along the floor of the radio room, tacked to the baseboard, or simply tossed out the window and supported a few inches above the ground. Two or more radials may be used for multi-band operation, each cut to one of the bands in use (fig. 2).

De-TVI-ing the Apartment or Home

Once your "invisible" antenna is operating properly with a reasonable value of s.w.r., it is a prudent idea to check the electrical wiring of the building for r.f. power that may be leaking into it from the nearby antenna. If the wiring is enclosed in metal conduit, this coupling is unlikely. Open wiring (knob-and-tube or *Romex*) can act as an unwanted pickup antenna, coupling a large amount of your precious output power into the neighbor's TV set or stereo! Sometimes r.f. pickup in the power line can be noticed when a lamp (supposedly turned off) glows when you are on the air. A fast and simple way to cure this problem is with a handful of .001 mf, 1.6 kv ceramic disc capacitors connected across the screw terminals of an empty line plug (fig. 3). The plugs are inserted in wall sockets at random until a position is found that "detunes" the electrical wiring in the building. Sometimes two or three plugs are needed to do the job properly.

"Invisible" Outdoor Antennas

If space permits, it may be feasible for the struggling amateur to string up an invisible outdoor antenna away from the building.[1] This is imperative if the building has a metal framework. The name of the game is to make the outdoor antenna invisible, or nearly so, to the casual observer. An effective way to do this is to use copper wire of very small diameter for the antenna. The writer has experimented with end-fed and dipole antennas made of soft drawn, enameled wire of #20 to #28 gauge (magnet wire). Other experimenters have made antennas of wire as small as #34 (removed by the mile from a defunct power transformer) with good results. Operation of "thin" antennas seems little to do with antenna wire diameter, although some antennas made of #34 wire have mysteriously

[1]The Handbook, "Simple, Low-Cost Wire Antennas," by W2LX and W6SAI is chock-full of "invisible" antenna ideas. Published by Radio Publications, Inc., Wilton. Conn., 06897 for \$3.95 plus 25c postage and handling.

[2]Another Radio Publications book. \$5.95 plus 25c postage and handling.

Mako's boy friend gets a new linear.

come down during the night. The only reason for this, it is guessed, is that birds can't see the wire either, and fly into it! Antennas made of #28 gauge wire don't seem to have this problem.

No problem with wire heating has been observed when running a few hundred watts input and the antennas seem to function as well as equivalent antennas made of "fatter" wire. In any event, regardless of power loss, antennas made with small diameter copper wire work, and in some instances are the *only* answer to a "tough" antenna problem.

Erecting the Invisible Antenna

Very small, hard-to-see insulators for the invisible antenna can be made out of ¼-inch diameter lucite or plastic rod. Make the insulator about 2 inches long and drill fine holes in it to accept the antenna and tie-off wire. Smooth the edges of the holes so that they do not chafe the wires.

The ends of the antenna should be tied off to points that will not impose a strain on the wire when the wind blows. Trees are poor tie-off points as they sway in the wind. Don't use a power or utility pole, tempting as it may seem. It is illegal to attach anything to a power pole. And in addition, it is dangerous and foolhardy!

In order to see the invisible antenna when you put it up, tie a long thread to a small piece of paper. Fold the paper and drop it over the center of the antenna wire. Once the antenna is up, you can remove the paper with a gentle tug on the thread.

As a starter, an invisible dipole made of #22 to #28 wire is recommended. You can use small-diameter RG-174/U coaxial line. The jacket of this line, unfortunately, is black and tends to stand out against the sky. The mini-coax is quite unobtrusive, however, against a darker background, such as a building, or a tree.

W6SAI would be pleased to hear from users of "invisible" antennas and to hear about their experiments with unusual antennas. Not everything is known about this interesting antenna technique and many questions remain to be answered. For each antenna idea published, the writer will be pleased to send an autographed copy of his new *VHE Handbook for Radio Amateurs*, written in conjunction with Herb Brier, W9EGO (of the *CQ* Novice Column), and just hot off the press! ■

antennas

BY WILLIAM I. ORR,* W6SAI

"WHAT are you reading, buddy?", asked Pendergast as he strode into the shack, thumbs tucked under his belt. He surveyed the room, which seemed to meet with his approval, as he settled into my favorite chair.

"I just got a copy of the new handbook, *VHF for Radio Amateurs* hot off the press. Herb and I wrote it."[1]

"Looks good. Very good", said Pendergast taking the copy from me and riffling through the pages. "One of these days I want to talk to you about Moonbounce antennas for 144 mHz".

"It's all in there", I replied. "What do you want to talk about today?"

"More about antennas, high frequency ones, that is. To be specific, do you have any more information on that 2 element HB9CV beam design? I'd sorta like to build one up for 6 meters, or maybe 15 meters. There's a lot of sporadic-E DX on 6 these days, and 15 is far from dead".

"Here's an interesting version of the HB9CV antenna, with dimensions for both 15 and 6 meters (fig. 1). The elements are made of light-weight aluminum tubing and are interconnected with a length of 300 ohm TV-type ribbon line and two gamma matching devices. Each element has its own gamma, made out of heavy aluminum wire, or small-diameter aluminum tubing." I handed Pendergast a drawing.

As if by magic, Pendergast produced his notebook and started to copy the drawing in it.

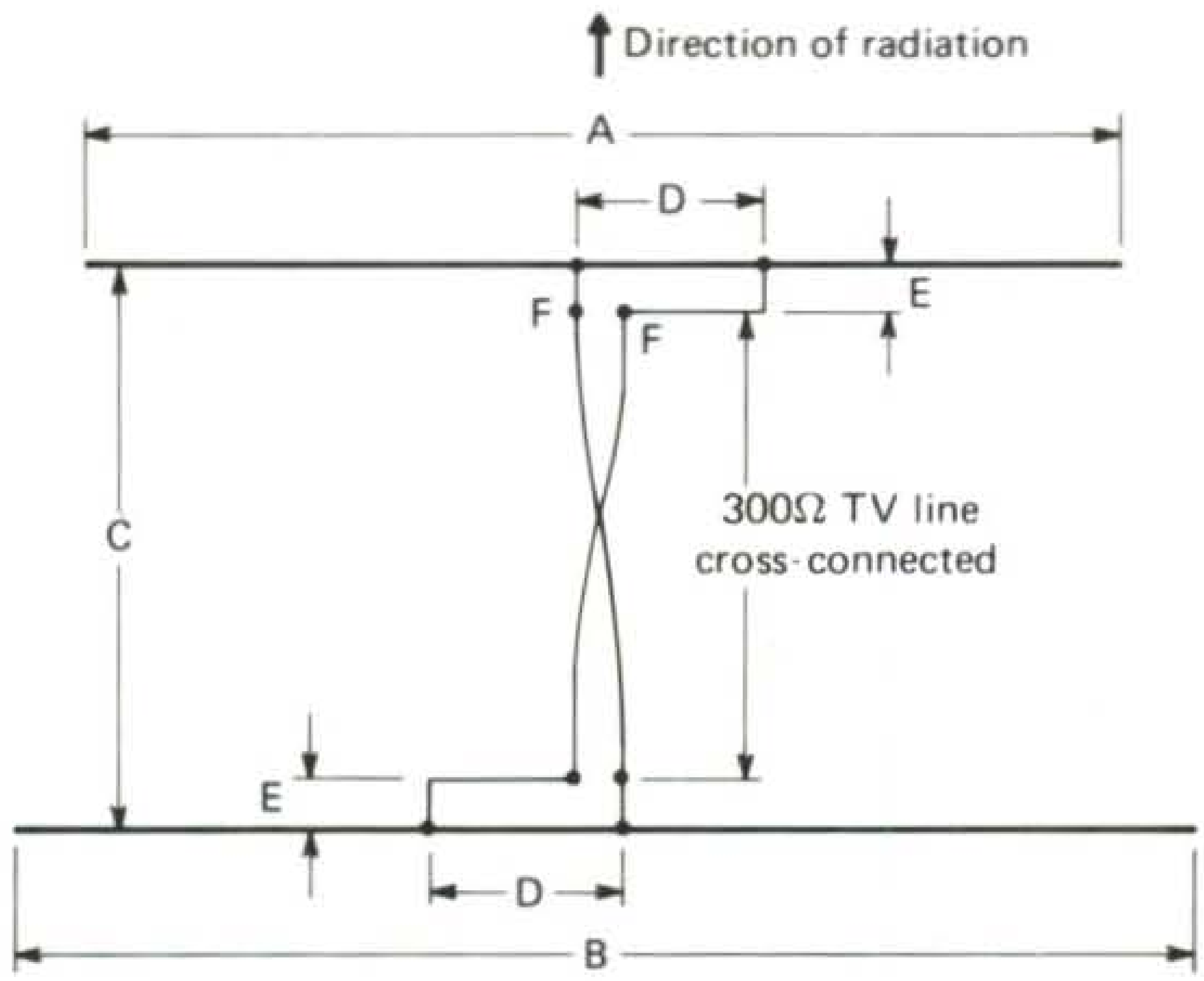
"The information came from a recent issue of *CQ·Ham Radio,* the nifty Japanese magazine". I opened a desk drawer and rummaged through a pile of papers and clippings.

"My filing system has broken down", I admitted. "I subscribe to a number of overseas amateur magazines and find them very informative and refreshing. I get a lot of good ideas from them, even if I can't read some of the magazines! You would be surprised at the number of ham magazines in the world. I file any good dope from them in this drawer".

"Let me look into that file of yours", said Pendergast. "You might have some goodies tucked away that I can add to my notebook." I relinquished the drawer to his easy grasp.

"Look at this," said Pendergast, waving a page torn from a magazine. "Here's a great idea for the assembly and construction of a four-band dipole antenna. This is a really nifty mechanical design (fig. 2). It would make a good portable antenna for Field Day work. From the Japanese magazine, too".

"I agree", I said. "It looks nice and is rugged. A good friend of mine, Bill Leonard, W2SKE, designed a similar antenna a few years ago for portable use. He did a lot of operating from hotels and was always on the go. His multiband dipole was designed for 20, 15 and 10 meters and was extremely light. It was made of 300 ohm twin-lead (fig. 3). Bill took a



Band	A	B	C	D	E
50mHz	9'3"	9'8"	2'6"	1'5"	2"
21mHz	22'4"	23'7"	5'5"	2'4"	4"

Fig. 1—Electrical details of the HB9CV beam antenna for 15 or 6 meters. Plan view, showing elements and feedline. Directivity is through element A (see arrow). Elements A and B are made of light weight aluminum tubing. The interconnecting feedline is made of a length of 300 ohm TV ribbon line. The elements are supported on a wood boom having the length indicated by dimension C. The elements are interconnected by means of two gamma matches (D) which can be made out of heavy aluminum wire, or small-diameter tubing. The transmission line s.w.r. may be adjusted by varying dimension D. A coaxial feedline and ferrite balun are connected at feedpoint F-F. In this design, the rear element is made longer than the front element to improve the front-to-back ratio of the array.

*48 Campbell Lane, Menlo Park, CA 94025.

[1]"VHF Handbook for Radio Amateurs," by Herb Brier, W9EGQ (Editor of *CQ's* Novice column), and Bill Orr, W6SAI. 336 pages, $5.95 plus 25¢ postage from Radio Publications, Inc., Box 149, Wilton, Conn., 06897

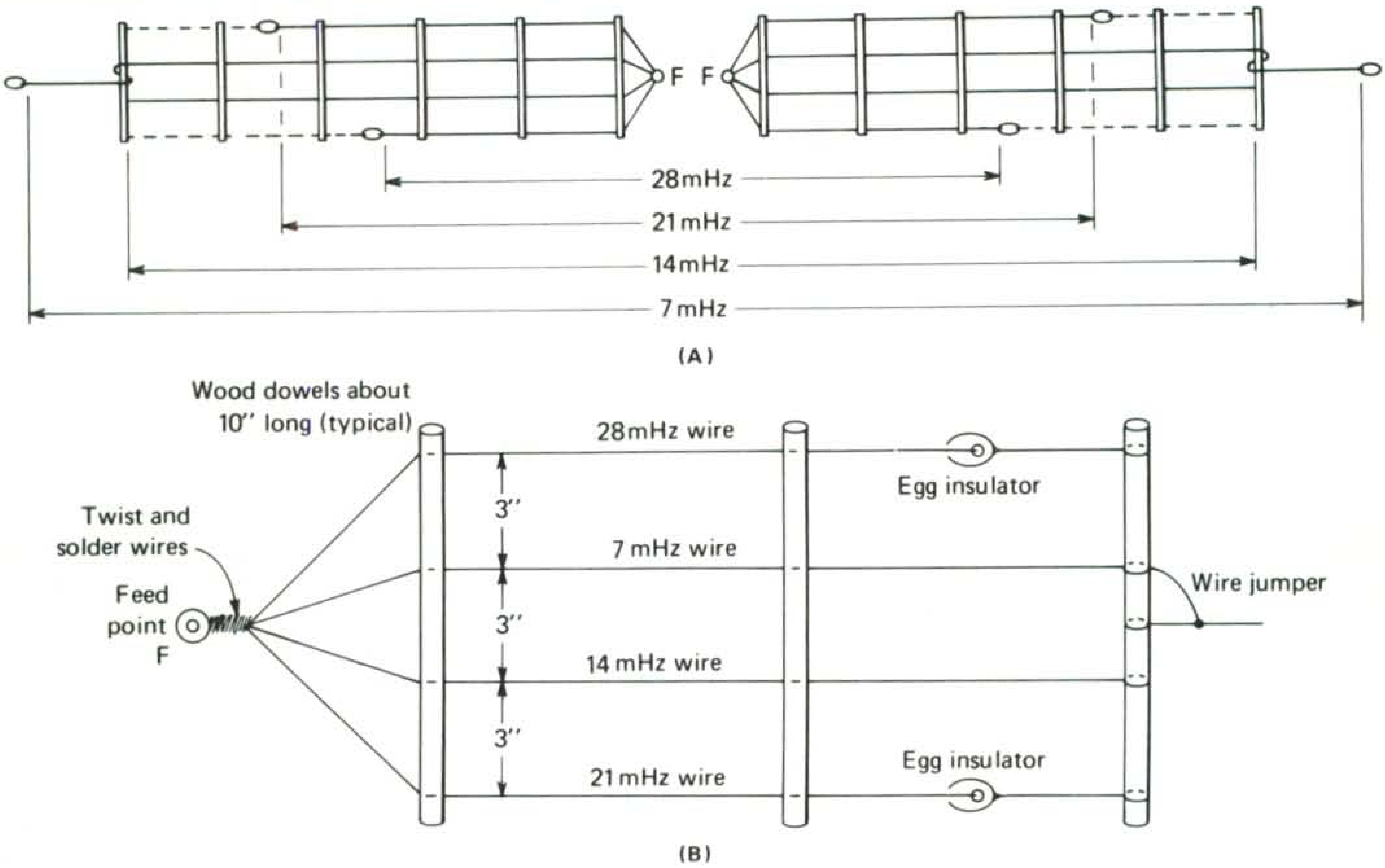


Fig. 2—Multiband dipole assembly. Four dipoles for the 40, 20, 15 and 10 meter bands are connected in parallel and fed at points F-F. The dipoles are supported in position by spacers made of 1" diameter dowel rod. The spacers are coated with waterproof epoxy to make them weather-resistant. The array is held in position by extension wires which form the outer portion of the 40 meter dipole. The extension wire is attached to the midpoint of the dowel so that the array is balanced and the tension on all wires is equal. The shorter dipoles are terminated with egg insulators and the outer (dotted) sections of the assembly are made up of additional lengths of wire. Rope should not be used as it will expand and shrink according to the amount of moisture in it. At the center of the assembly, the dipole wires are twisted and soldered together and the halves of the antenna are fed with a 50 ohm transmission line. A ferrite balun may be used, if desired. Dipole lengths are conventional. Complete assembly is shown in illustration (A) and simplified view of one half is shown at (B).

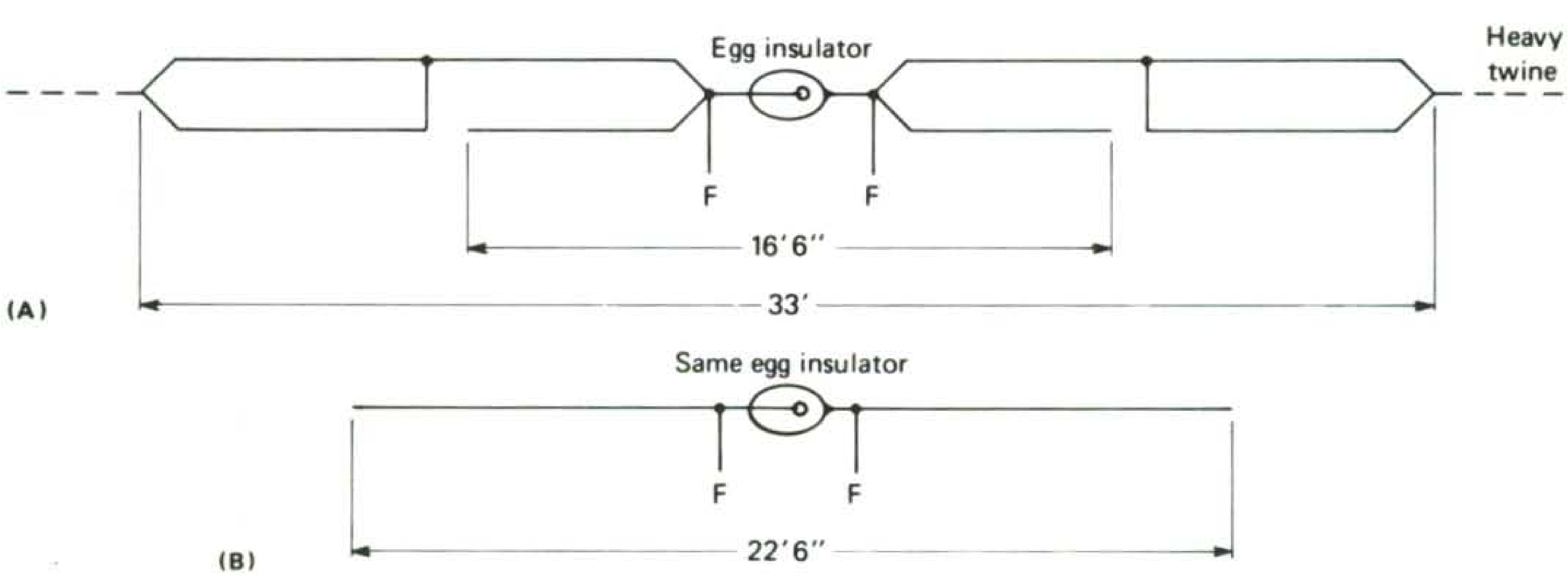
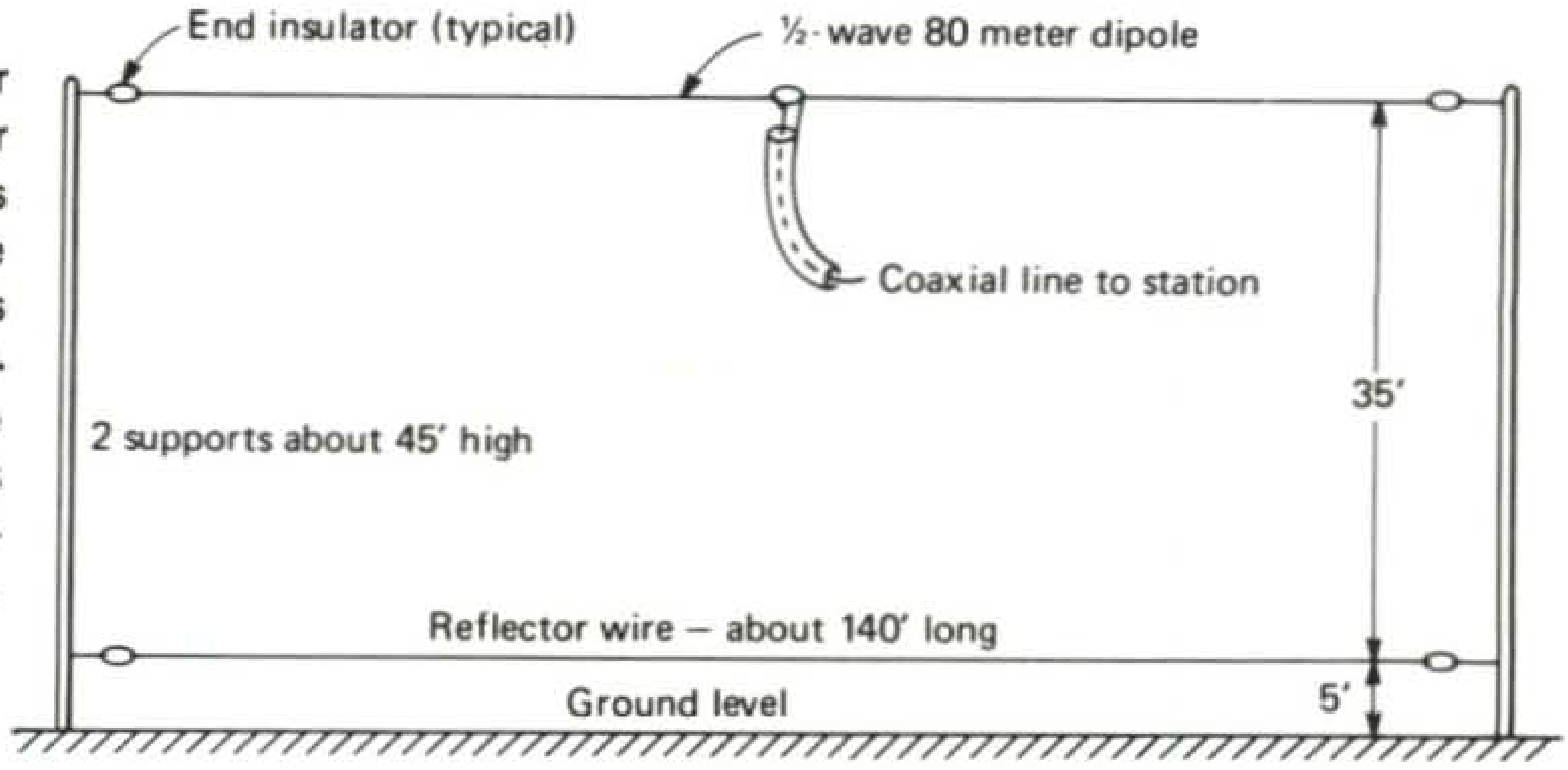


Fig. 3—Assembly of 20-15-10 meter dipole. (A) Twenty and ten meter sections are made of 300 ohm ribbon line. One leg of line is broken on each half of the assembly to form the 10 meter section. The unused outer tips are connected back to the 20 meter section to prevent the antenna from tearing apart under tension. Only a small segment of wire is cut free at the break, leaving the center webbing intact. (B) A 15 meter section is added to the ribbon dipoles, made of lengths of insulated wire. The 15 meter antenna is taped to the ribbon dipole and connected in parallel with it at feedpoints F-F. The triband antenna is fed with a random length of RG-58/U coaxial line.

Fig. 4—80 meter dipole array for short range work. Single reflector wire below dipole concentrates high angle energy to improve short range signal. Some versions use 5 or 10 reflector wires. Reflectors are not grounded. Care should be taken so that the ends of the reflectors cannot be touched as they are at a high r.f. potential.



length of ribbon line 33 feet long, shorted the ends and placed an insulator at the center. This made the 20 meter section. One wire of the twin-lead was cut 8'2" on each half of the dipole and the *outer section* wire was cleaned of insulation for about a half an inch, and soldered to the 20 meter wire for added strength. This allowed the short center section wire to function as a 10 meter dipole. Finally two 11'2" sections of insulated hookup wire were taped along the twin lead, each side of the center insulator, and the inner ends soldered to the common joints at the insulator. This made up the 15 meter section. The wire was taped to the twin-lead every foot. The last step was to attach a length of RG-58/U coaxial, 50 ohm transmission line across the center insulator. The whole assembly was very light, and W2SKE carried it all over the world for quickie operation from temporary locations".

There was a long silence as Pendergast's pencil scratched in his notebook. Finally, he asked, "Didn't he use a balun?"

"No," I replied. "No balun. With low power and a temporary lash-up like this, a balun really is more of a nuisance than a help. It adds weight to the center of the antenna. W2SKE slung his antenna up with string and when he was ready to leave the air, a quick tug on the coax line brought the whole thing down".

"What else do you have", said Pendergast to himself, as he leafed through an assortment of papers. He paused, and pulled one out.

"Hey, I like this", he said. "Here's a drawing of a short-haul 80 meter antenna (fig. 4). It consists of a 2 element beam, aimed straight up so as to bounce a strong signal off the ionosphere, directly overhead. It should be a "bomb" within 1000 miles or so."

"I heard some fellows on 3995 kHz using antennas of this type", I said. "They were back east and really put out a good signal, even as far as the West Coast. So the antenna really is better than just a 'local' antenna. It works for long skip, too".

Pendergast paused in his search through the papers. "Have you received any interesting mail?", he asked.

"Yes", I replied. "By coincidence, in the same mail, I received letters from the Chief Engineers of two antenna manufacturing companies. Both of the companies make a wide line of antennas for radio amateurs. For each company, the most popular antenna sold is the inexpensive 3-band vertical that works on 10, 15 and 20 meters. In one case, the vertical employs traps for bandswitching, and in the other case, the vertical has a tapped base loading coil."

"Well, what was the problem?", asked Pendergast, putting down the notebook. "That seems like a pretty simple antenna to get going!"

"Apparently not", I replied. "More antennas of this type are sold than any other type, and a large percentage of them go to Novices and beginners who don't have a lot of expertise in putting up an antenna. They run into trouble, get angry when the antenna doesn't seem to work, then send off a fiery letter to the antenna manufacturer."

Pendergast took the two letters and read them carefully. "Very simple", he said. "My motto is: *as a last resort, read the instruction manual*".

"That's part of the problem", I replied. "The anxious amateur, with a new antenna in his hot little hands, rushes out and tries to put it up, without first reading the assembly instructions. Look at this: here's a list of antenna problems compiled by one manufacturer from the complaints he has received about a 3-band vertical antenna.

Problem #1. The user forgets to install radials, or forgets to make a ground connection at the base of the antenna.

Problem #2. The user installs the antenna along the side of a building, thus detuning the antenna.

Problef #3. The dimensions given for the antenna are ignored.

Problem #4. The user expects the vertical antenna to be competitive with his neighbor's 4 element beam installed 120 feet above ground.

"The Engineer of one antenna company lets

[*continued on page 78*]

Antennas [*from page 41*]

his hair down and says in his letter (quote) I think the whole problem goes back to the basic reluctance of some amateurs to read beyond the ARRL license manual. In addition, the ham often needs a little short course on how to get the most for your money and how to get the best results for your purchase (unquote)".

Pendergast said nothing, so I continued. "A lot of fellows don't realize that when they erect a vertical antenna, regardless of whether it is a 3-bander, or whatever, that *they have only half an antenna.* The ground system makes up the other half, and is as equally important as the antenna!

"Every amateur using a vertical antenna should read the series of articles by Jerry Sevick, W2FMI, which have appeared in *QST* over the past year or two. He explodes a lot of the myths about vertical antennas. His measurements show that a *good* ground return system can improve the performance of a vertical antenna by about 8 decibels, and that's the equivalent of adding a linear amplifier to your exciter!

"Jerry says his experiments show that, aside from lightning protection, the use of a ground rod with a vertical antenna is of questionable benefit. I agree completely with that. It is extremely difficult, if not impossible, to get a good, low resistance r.f. ground connection with a ground rod and the only alternative is for the user of a vertical antenna to go to a radial system of some sort, even if the antenna is ground mounted on a short post."

"The effective conductivity of sea water, which is assumed to be a good ground, is about 5000 millimhos/meter. In the United States, ground conductivity varies from 4 millimhos/meter in dry, sandy areas such as Nevada to 30 millimhos/meter in moist, farmland-type ground. And as a matter of fact, the moist ground isn't so good, either. In one instance, measurements were made over moist farmland in comparision against salt water.

The moist farmland didn't do so well . . . down about 5.3 decibals, in fact. The loss over ordinary urban ground is anybody's guess.

"While the user of a vertical can't do much about ground loss in the far-field of his antenna, he can do a lot about ground loss in the immediate vicinity of the antenna. And, as Jerry's articles show, a good radial system is the key to good operation. You can use a ground rod if it makes you happy, but you had better back it up with some radial wires.

"At the *very minimum,* at least one radial wire is required for each band or the antenna just won't work. I discussed this in my July *CQ* column. You can get by with a single radial wire for 10, a single one for 15, and a single one for 20, all tied together at the base of the 3-band vertical antenna. Now, *Hy-Gain,* for example, recommends a minimum of *two* radial wires for each band. Each radial, you understand, is a quarter-wavelength long at the operating frequency. Many designs, however, show four quarter-wavelength radials as the recommended minimum. Personally, I don't think there is much difference in performance between one, two or four radials".

I paused, and Pendergast asked, "What does W2FMI recommend?"

"Well, it seems to me that his data showed that 10 radials were a great improvement over 4, and 40 radials were a great improvement over 10. Using 100 radial wires was about 8 decibels better than using 4 radials."

"Well, what do *you* do at your summer home?", asked Pendergast.

"I use a vertical antenna there, a sixteen foot whip for 20 meters," I replied. "The ground is fairly flat, with no real, metallic obstacles around the antenna. The antenna is mounted on a post driven into the ground, and the base of the whip is only about six inches above the grass. I have 8 radial wires, made of 16′6″ lengths of insulated hookup wire. These are insulated at the free end, and the other end has a copper alligator clip on it.

"When I'm not on the air, the radials are rolled up and tossed under the house. When I go on the air, I take them out, spread them over the lawn and clip them to the shell of the coaxial connector that is attached to the base of the vertical antenna.

"The whip is attached to the post with wing nuts, so when we leave the place, it only takes a few seconds to remove the whip and stow it away."

"And how does it work?", asked Pendergast.

"As well as can be expected", I replied. "I can't compete with DXers using elevated beams, but I can work a lot of DX and I have a lot of fun with it. Maybe I could pick up a few more decibels by adding more radial wires, but eight is a nice, round number and not too messy."

I got up as Pendergast started to walk towards the door.

"I admit, the vertical antenna can't compete with a good beam. But the ionosphere, is a great leveler of signals and sometimes you are surprised. Last spring I pulled 9N1MM, Father Moran in Nepal, out of a pile-up using this vertical, so the antenna must be doing some good".

Pendergast paused as he opened the door. "The vertical has some distinct advantages", he said. "It is inexpensive, unobtrusive and takes up little space. Sometimes it is the only antenna that the amateur can put up, because of property restrictions or other problems. After all, that's the game to play if it's the only game in town". ■

antennas

BY WILLIAM I. ORR,* W6SAI

PENDERGAST hung up the telephone with a sigh and rubbed his ear.

"Who were you talking to?," I asked. "You've been on the pipe for over an hour. I drove over here to see if your line was out of order."

Pendergast sighed again. "That was Hardcore pounding my ear. That guy is continually enmeshed in antenna problems. He got beat out on 40 meters trying to work Kingman Reef. He's fit to be tied."

"Poor operating habits," I replied. "A friend of mine worked Kingman with 10 watts and an indoor dipole on 40 meters."

"Well," replied Pendergast crossly, "that wasn't *me*. I missed him on 40 meters, too. Just couldn't cut the QRM. I guess both Hardcore and I need 40 meter beams. Do you have any designs for a compact 40 meter beam, about as big as a 10 meter beam, and with 10 decibels gain and 50 decibels front-to-back ratio?"

*48 Campbell Lane, Menlo Park, CA 94025.

"Not yet," I laughed. "Remember my beam antenna theory: the gain and effectiveness of a beam antenna is proportional to the size and to the time and trouble it takes to erect it."

"That sounds like the v.h.f. man's theory: if the antenna doesn't come down in a storm, it isn't big enough!," replied Pendergast.

"Right," I said. "However, to get back to Hardcore's problem, I suggest that he should think about a compact, two-element 40 meter beam. The crux of the problem, of course, is how 'compact' is compact? How much can you 'shrink' a beam before it becomes merely a toy? I've seen some pretty small beam designs that are extolled as being effective, but when the chips are down, they don't perform as well as a dipole.

"Problem is, the radiation resistance of a full-size two or three element beam is only 20 to 25 ohms at best. When you start reducing the size of the beam by introducing loading coils, the radiation resistance drops rapidly. While I've seen no information on the reduction of radiation resistance for miniature beam antennas, I do know that reducing the size of a vertical antenna by one-half drops the radiation resistance by two-thirds. An eighth-wave vertical antenna, then, has a radiation resistance of about 10 ohms, as compared to 35 ohms for a quarter-wave vertical."

"Do you think the same reduction factor applies to a beam antenna?," asked Pendergast.

"Well, perhaps not exactly," I replied, "But the reduction factor is of the same order of magnitude. If so, a half-size two or three element beam has a radiation resistance in the neighborhood of seven to eight ohms."

"Nonsense!," replied Pendergast. "Most minia-

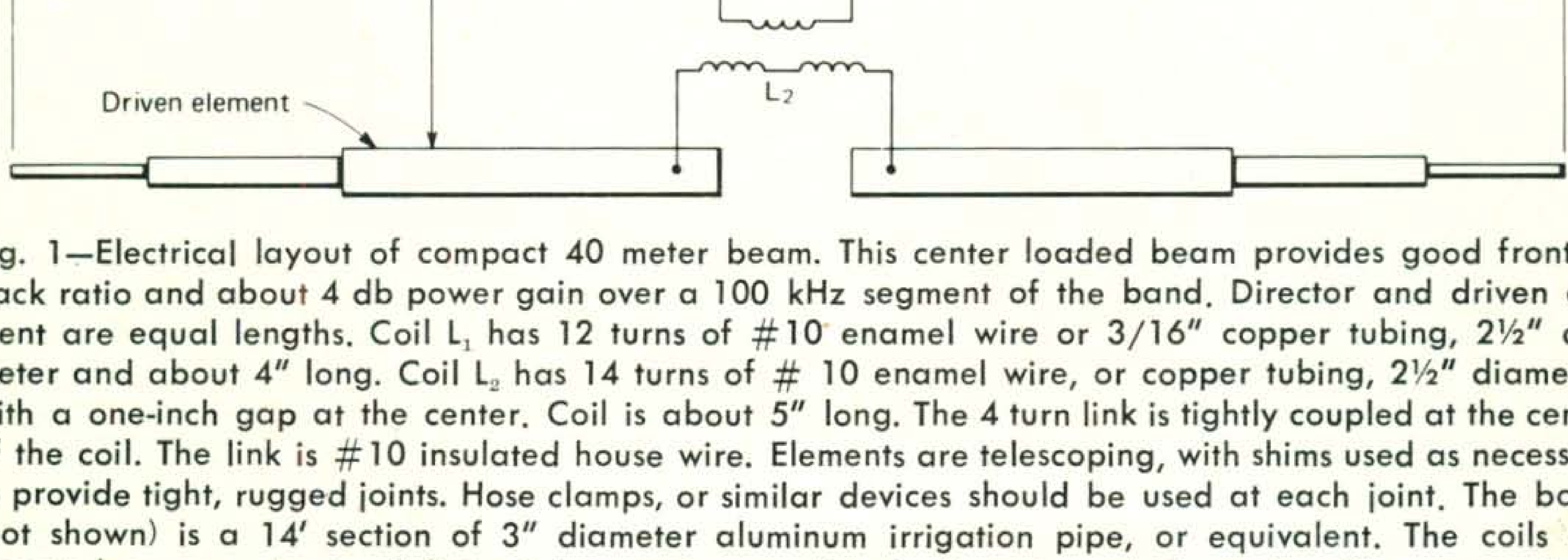


Fig. 1—Electrical layout of compact 40 meter beam. This center loaded beam provides good front-to-back ratio and about 4 db power gain over a 100 kHz segment of the band. Director and driven element are equal lengths. Coil L_1 has 12 turns of #10 enamel wire or 3/16″ copper tubing, 2½″ diameter and about 4″ long. Coil L_2 has 14 turns of # 10 enamel wire, or copper tubing, 2½″ diameter, with a one-inch gap at the center. Coil is about 5″ long. The 4 turn link is tightly coupled at the center of the coil. The link is #10 insulated house wire. Elements are telescoping, with shims used as necessary to provide tight, rugged joints. Hose clamps, or similar devices should be used at each joint. The boom (not shown) is a 14′ section of 3″ diameter aluminum irrigation pipe, or equivalent. The coils are mounted on ceramic standoff insulators and connection to the elements is made with copper strap. The beam is fed with a 50 ohm coaxial line at points F-F.

ture beams provide a very good match to a 50 ohm coaxial line."

"You forget the miniature beam uses loading coils or other devices to establish resonance," I countered. "Loading coils can be very lossy, and the loss resistance must be added to the radiation resistance to give a true picture of the feed point resistance of the beam. The loss resistance can be as high as, or higher than, the radiation resistance. Most of the applied power is used up in warming the loading coils. You have to be very careful to design high-Q loading coils for *any* miniature beam, otherwise the miniature beam will exhibit signal loss, instead of signal gain."

Pendergast paused as I pulled a photograph and a drawing out of my brief case. "Here's a good design for a compact 40 meter beam that you can pass along to Hardcore (fig. 1). It is a center-loaded beam that provides good front-to-back ratio and about 4 decibels power gain. It is a rugged beast, and only a little larger than a typical triband beam. Best of all, it is easy to construct and adjust and won't come down in a storm, if it is properly built."

I pointed to the drawing. "A beam antenna of this design was used by Project Oscar station W6EE for their 40 meter RTTY schedules a few years ago. Anyone who heard the W6EE signal on the east coast, and in Europe on 40 meters can tell you that this beam has real punch!"

Pendergast studied the drawing as I continued, "The beam is built on a 14 foot long boom made of 3-inch diameter aluminum irrigation pipe. Each element is insulated from the boom and loaded at the center with a high-Q loading coil. The elements are broken at the center and an insulating plug is used to hold the halves together. The W6EE design used a piece of fibreglass tubing as the center insulator, but any material such as hard wood, micarta or the like can be used, as long as it does not absorb water.

"Each element is 45 feet long. The inner sections are 1½" diameter tubing, the next sections are 1⅜" diameter and the tips are ⅞" diameter. This makes a surprisingly rigid element that doesn't have much sag to it."

"You say both elements are the same length?," asked my friend. "How, then, good Sir, does this device act as a beam?"

"The elements are resonated to the proper frequencies by means of the center loading coil," I replied. "The director coil has 12 turns and the driven element coil has 14 turns. Each coil is 2½" in diameter and about 4" long. Number 10 wire is used for the coils, which are air-wound.

"The coils are mounted on 3" high standoff insulators and connections are made from the coil to the element with ½" wide copper straps. Each strap is 5" long."

Pendergast scribbled furiously away in his notebook, as I continued. "The driven element coil has a one-inch space at the center, and a 4

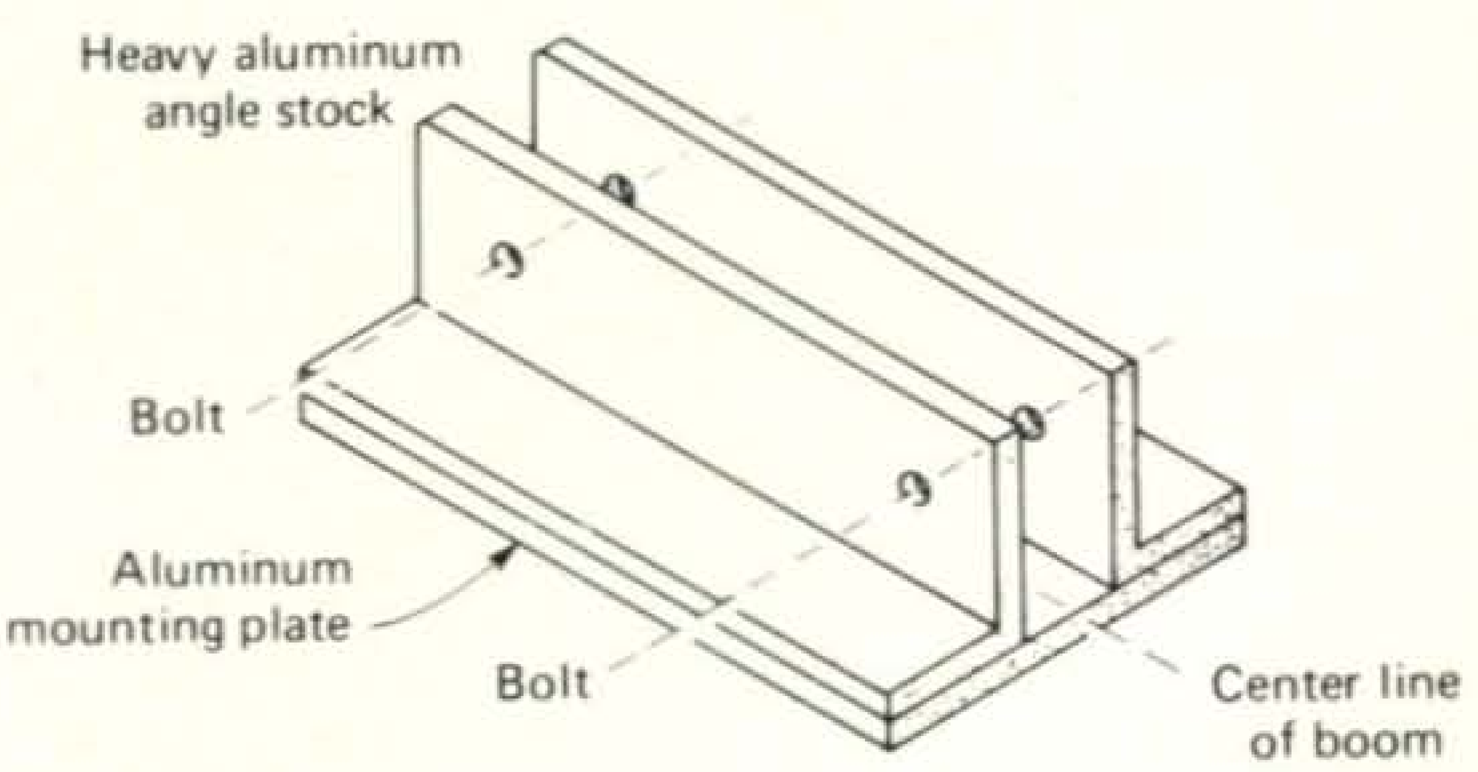


Fig. 2—Mounting bracket for beam. An aluminum "cradle" can be assembled out of a flat aluminum sheet and two pieces of heavy aluminum angle stock. The pieces are held together with heavy bolts. The boom fits snugly between the plates and is held in position with two bolts passed through the boom. The aluminum plate can be fastened to the support structure by conventional means. When the bolts are withdrawn, the boom may be slid back and forth in the cradle so that the operator may make adjustments to either the driven element or the director. A safety strap may be passed over the cradle to hold boom in horizontal position.

turn link is placed in this gap. The link is directly attached to the 50 ohm coaxial transmission line. The link is wound of #10 insulated house wire and is positioned so that it falls neatly inside the space in the center of the coil."

After a pause, Pendergast inquired, "Is that all?"

"That's all," I replied. "The usual details of mounting the elements to the boom, and the boom to the mast I leave to your imagination."

"Hold on!", shouted Pendergast. "How do you adjust the beam?"

"The beam should be on the tower, or at least in the clear, and elevated 20 or 30 feet above the ground. The director is self-resonant about five percent higher in frequency than the chosen design frequency. The operational bandwidth of the beam is about 100 kHz; fifty kHz either side of the design frequency. The SWR on the transmission line is less than 2 over these limits. If, for example, your design frequency is 7250 kHz, the director element is self-resonant at approximately 6890 kHz. The turns on the loading coil are expanded or compressed until this frequency is achieved."

"How do you determine this adjustment," asked Pendergast.

"With a grid-dip meter," I said. "Listen to the grid-dip meter in a nearby, well calibrated receiver. Couple it lightly to the loading coil of the director and tune for the resonance dip. Note the frequency of the dip on the receiver. If you do this carefully two or three times, you can estimate the resonant frequency of the director within two or three kilohertz. Adjust the coil—or the element length—until resonance is achieved."

"And the driven element?," asked Pendergast, scribbling away in his notebook.

"Same technique. The coaxial line is removed, and the center coil adjusted to the design frequency of 7250 kHz. Then the line is attached and the beam hoisted to its final position. Minor adjustment can be made by moving the position of the link coil with respect to the main loading coil."

"And how do you make these foxy adjustments when the beam is atop a fifty foot tower?," demanded Pendergast.

"That's one of the prices you must pay for a good, compact beam that *works,*" I replied. "If you don't want to adjust it, why don't you go out and buy a pre-adjusted beam?"

Pendergast did not reply, so I continued. "One way of adjusting the elements for resonance is to make the boom-to-mast joint adjustable. Look at fig. 2. By removing two bolts, the boom can slip back and forth in a collar. You want to adjust the director? Fine, pull the bolts, and slide the boom in, bringing the *director* close to the tower. You want to adjust the driven element? pull the bolts and slide the boom out, bringing the *driven element* close to the tower.

As I closed my brief case, I said, "Don't forget to get this baby up in the air. A half-wavelength on 40 meters is about 70 feet. If this beam is much lower than that, you won't get maximum performance out of it."

"Hardcore has a 72 foot crank-up tower," replied Pendergast. "He can put the beam on when the tower is cranked down to 22 feet, then run it up to full height. He'll blow your head off when he gets this working!"

"Before I leave, I want to show you a drawing of the great antenna installation that W6CYL has on his mobile home. This is a real clever answer to a tough problem (fig. 3).

"Bob has a sixty-foot mobile home in a classy trailer park. And the owner doesn't permit any ham antennas! In fact, the owner of the park is ex-Navy and he can spot a ham antenna a mile away. Well, Bob is ex-Marine, and he doesn't take any static from a Navy man, so he's on the air with a disguised antenna installation that is a real winner! The owner of the trailer park allows TV antennas, since there's no cable TV. So Bob disguised his ham antenna to look like a TV installation. In fact, that's what it is! Look at this."

I waved the photograph under Pendergast's nose. "Observe the twenty foot mast with a v.h.f. and u.h.f. TV stack at the top. Observe the black box under the antennas. That looks like a TV rotator, but it is a decoy, made of aluminum and wallboard, and has a balun inside it for the ham antennas."

"Where are the antennas," asked Pendergast. "Does Bob use the mast for a vertical?"

"No way," I replied. "He tried that, but had too much TVI. So he uses the guy wires. There are four top guys, each one runs to a corner of the mobile home. Two of the guy wires form a 20 meter dipole and two of them form a 40 meter dipole. And two of the lower guy wires form a 10 meter dipole. The 40 and 20 meter dipoles are connected in parallel at the feedpoint and are fed through the balun. The 10 meter dipole has no balun, but is fed directly with a separate coaxial line."

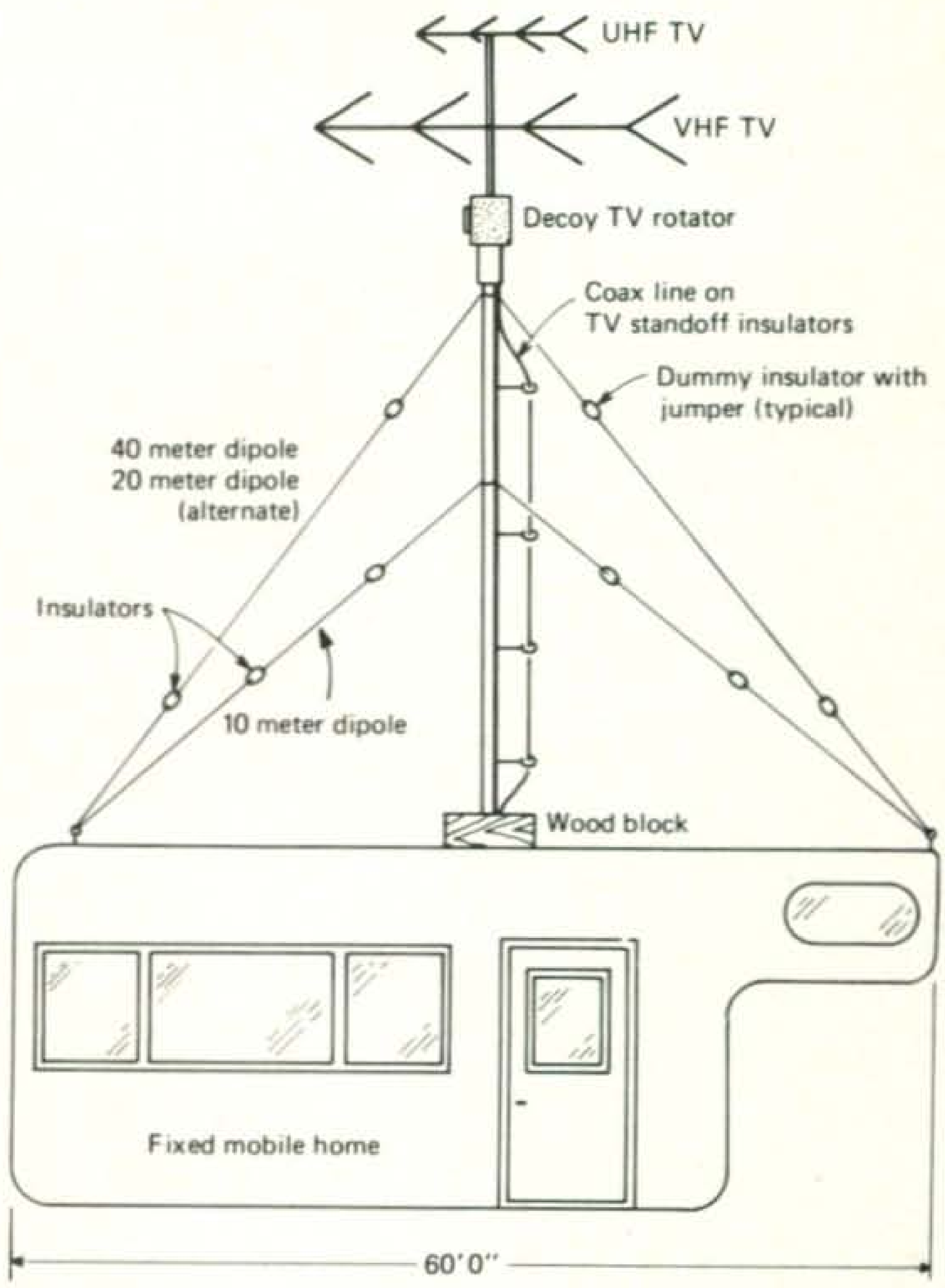


Fig. 3—The Mobile Home Antenna installation of W6CYL. No ham antennas allowed in this classy trailer park, but TV antennas are OK! So W6CYL made his TV installation into ham antennas for the hf bands. See text for construction details.

"But they can't be dipoles," protested Pendergast. "The guy wires are all broken up with egg insulators!"

"Ah, yes," I replied. "But all of the egg insulators are *decoys,* except the ones at the end of the dipoles. The antenna wire merely passes *through* the phoney egg insulators and continues on its way."

"So the guy wires are the dipoles," exclaimed Pendergast.

"Right. Bob has trimmed the 40 meter dipole so it also works on 15 meters, on the third harmonic. The feedlines for the antennas, and for the TV antennas as well, are brought down the mast on standard eye bolts. The whole works looks like a TV installation, even to the dummy rotator atop the mast.

"And to add insult to injury, Bob uses the plumbing system for a ground and then loads the

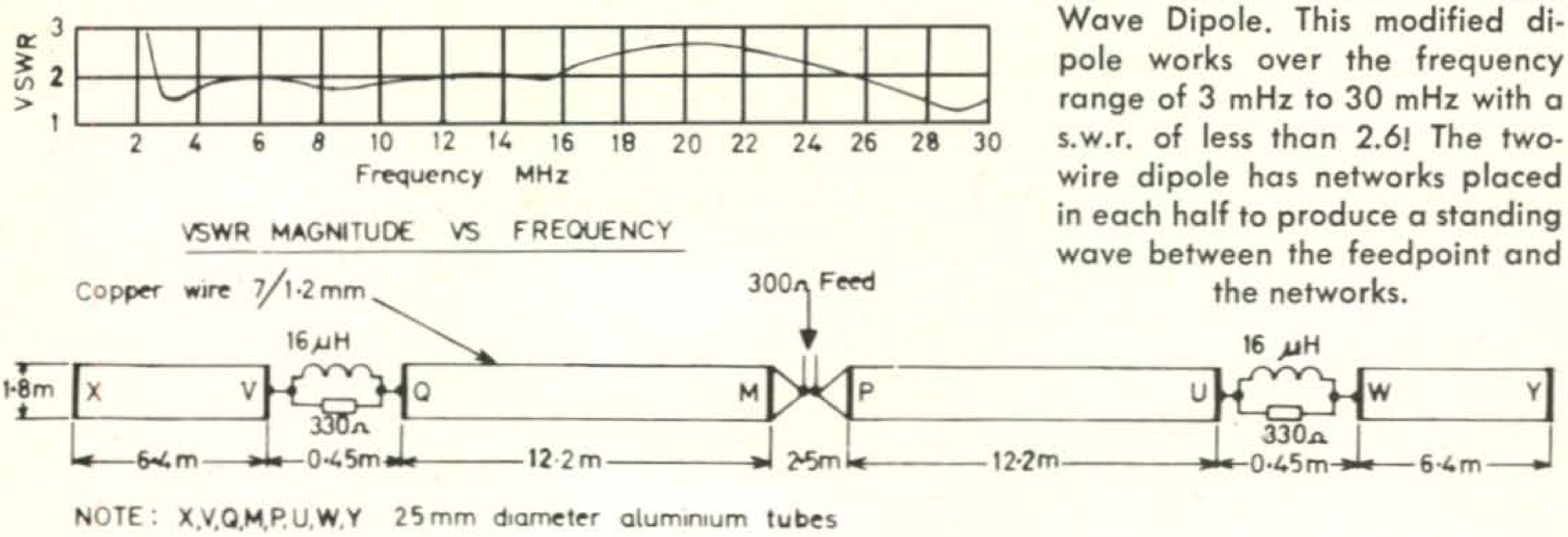


Fig. 4—The Australian Travelling Wave Dipole. This modified dipole works over the frequency range of 3 mHz to 30 mHz with a s.w.r. of less than 2.6! The two-wire dipole has networks placed in each half to produce a standing wave between the feedpoint and the networks.

dipoles on 80 meters! He ties the braid to the center conductor at the bottom end of the feedline and, in conjunction with a loading coil, works the 40 meter dipole as a top-loaded antenna on 80 meters! The feeline does most of the radiating, and the dipole merely acts as top loading."

"How about TVI on 80 meters?," asked Pendergast.

"Bob says he has a slight herringbone on his own TV set, but his next door neighbor reports clear reception."

"Amazing," said Pendergast," especially since the TV down lead is within inches of the 80 meter radiator!"

"Yes, it is," I admitted." Bob has a high-pass filter on his TV set, and a low-pass filter on his transceiver. So he is pretty clean. But he can work all bands from 80 to 10 meters. And do you know what?"

"What?," breathed Pendergast.

"To top it all off, Bob uses the v.h.f. TV antenna for 2 meters and works into all the local repeaters!"

"How does he do that?," asked Pendergast. "The TV antennas are horizontally polarized!"

"Who knows?," I replied. "All I know is that everything *works*, and Bob is on the air, under the very nose of the ex-Navy trailer park owner, who makes formal, white-glove inspection every day!"

The woods are full of clever people," said Pendergast. "And now I have one for *you*. Bet you never saw *this* antenna!" He dropped a magazine in my lap. It was the April, 1974 issue of *Amateur Radio*, of the Wireless Institute of Australia.

"The antenna was described at the August, 1973 Convention of the Institute of Radio and Electrical Engineers in Melbourne, and the article in *Amateur Radio* is a summary of the IREE paper given by Dr. R. Guertler and G. Collyer of the Antenna Engineering Company of Australia."

I looked at the drawing (fig. 4). "I'll be damned," I said. "This is a broad band dipole that covers 3 to 30 mHz! Fantastic!"

I read from the article:

"The dipole was designed for short-haul h.f. communication systems and is supported in a horizontal position between two masts. The feed point impedance provides a good match to a 300 ohm balanced line, or may be matched to a 70 ohm coaxial line by means of a balun."

"Go on," said Pendergast. "What does it say about the networks?" I continued:

"Firstly, there is a 12.1 meter (39.7 feet) length of two-wire line spaced 1.8 meter (5.9 feet) by means of two 25 mm. (1") diameter aluminum tubes. The wire is 7 strands of 1.2 mm. diameter copper. A tapering section of 1.25 meters (4.1 feet) brings the wires together at the feed point. At the other end of the open wire section there is a network which connects to another section of open wire line 6.4 meters (21 feet) long. The network consists of a 16 μH inductor in parallel with a 330 ohm resistor and takes up a length of 0.45 meter (1.4 feet, including connections). Overall the antenna is 40.6 meters (133.25 feet) long."

"What about the network?," asked Pendergast, nervously chewing on a pencil.

I continued:

"It was found that neither the value of the 330 ohm resistors nor that of the shunt inductors was very critical. The shunt inductor has a small effect on s.w.r. at the lower frequency end. However, reduction of the resistance to 150 ohms caused the s.w.r. to fluctuate considerably with frequency. The taper sections were required to reduce shunt capacity between spreaders M and P. Reducing the length of this section produced an increase in s.w.r."

"Wow!," said Pendergast. This looks like the long-missing all-band antenna. Imagine, this antenna can work on all ham bands between 80 and 10 meters, and all frequencies in between! Feed it with a 70 ohm line and a 4 to 1 balun! You've got it made!"

He gathered up his belongings and made a rush for the garage workshop. ■

* * *

W6SAI note to readers: I would be interested in hearing from any experimenters who try out this unique antenna design. No additional information, other than that in this column, is available at the present time.

antennas

BY WILLIAM I. ORR,* W6SAI

"My friend, you look very sad." Pendergast tossed aside the copy of *Appliance Operator* magazine he had been reading and took his feet off the operating table. "I was just looking at the ads for the Pachenko machines."

"What's a Pachenko machine?," I asked.

"A Japanese transceiver with solid-state readout. The word *Pachenko* means pin-ball machine in Japanese. You know, one of those things with lights and bells. Well . . ."

"I see the comparison," I said.

"Enough of this chatter. Tell old Pendergast your problem," said my friend.

"Well, old Pendergast, I sort of worked myself into a box with my recent *CQ* columns," I replied. "In the last few issues I discussed the so-called invisible antenna and the problems some hams have in erecting a good antenna in the face of building restrictions, suspicious landlords and the like. Obviously I hit a vital point. Some hams have single story homes with a height limit of 16 to 26 feet on buildings and accessories. Some have a restriction on antennas of any kind. It's a tough situation."

"Well, how about the good old, reliable ground plane antenna," demanded Pendergast. "That's not very high for 20 or 15 meters, and it is inconspicuous. In fact, *you* have one of them, don't you?"

"Yes," I admitted. "I have a 21 mHz ground plane at my vacation spot and it has worked well for years. The base is very close to the ground however, and I have always been very uneasy about it, especially after reading W2FMI's very fine series of articles about vertical antenna systems in *QST* over the past few years. Jerry proved that a ground-mounted vertical antenna needed a large number of radials before it worked efficiently. The garden variety of amateur ground plane—with 3 or 4 radials—mounted close to the ground exhibited about 8 db less signal strength than a similar antenna mounted over a good ground plane."

"Yes," said Pendergast. "I remember you saying in your September *CQ* Antenna column that a ground plane vertical is only half of an antenna system and the ground radials (or screen) make up the other half."

"Right," I replied. "Well, to try and get around the problem, and to make a better low-profile antenna, I could either add a lot of radials, or try another approach. So I took down the 21 mHz ground plane—it only had 4 radials—and in its place I put up a vertically polarized Quad loop antenna (fig. 1) at about the same height. The Quad loop exhibits about 3 db gain over a ground plane and the loop is a complete antenna so the electric field does not have to penetrate the earth to reach the missing portion of the antenna, as is the case with the ground plane. The loop antenna, in itself, is a complete entity. Hopefully, then, the electric field losses inherent in the ground

*48 Campbell Lane, Menlo Park, CA 94025.

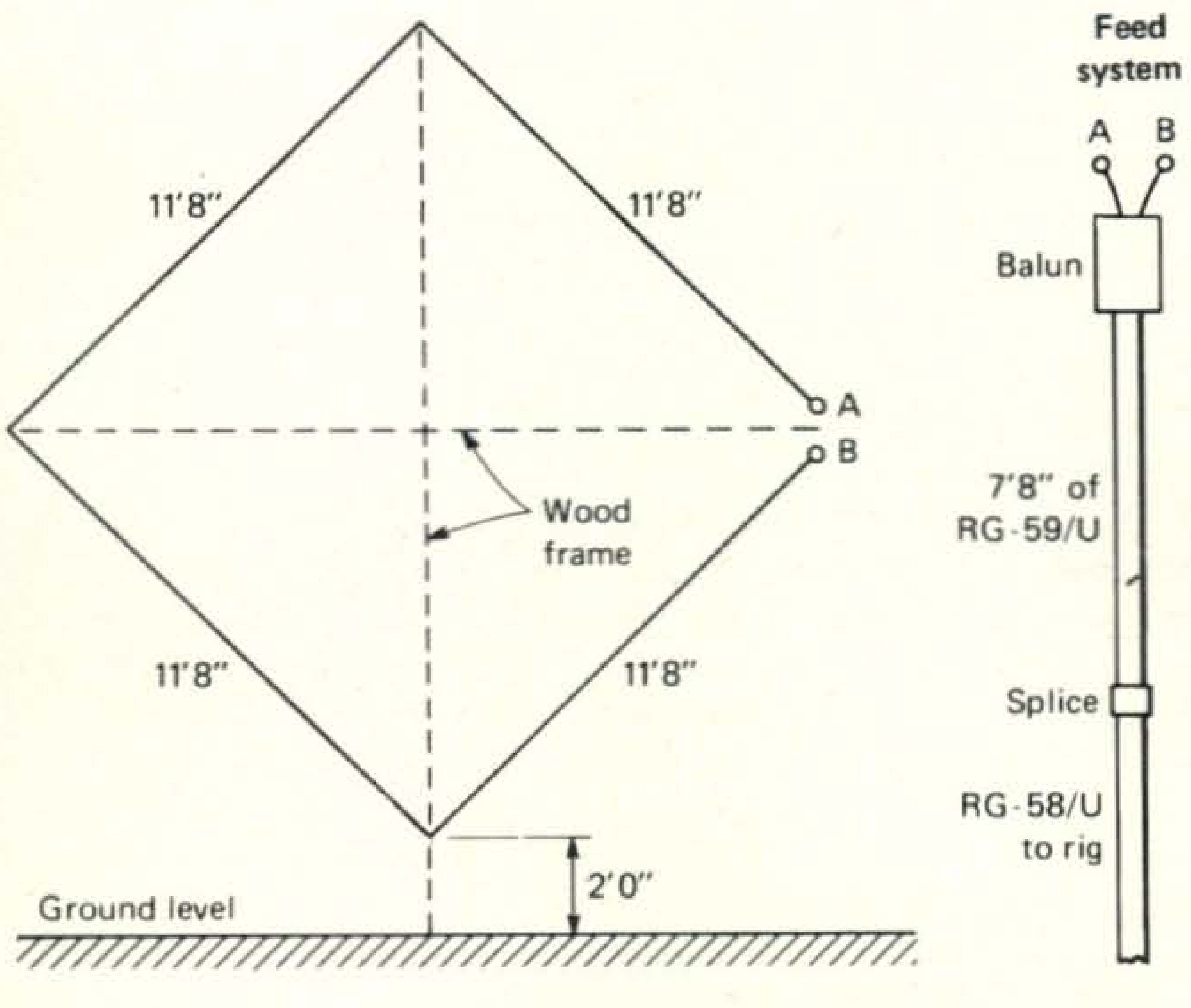


Fig. 1—The single quad loop antenna. This experimental loop antenna was mounted on a wood mast about 18 feet high. Loop was made of #18 wire, 11'8" on a side. The low point of the loop was about 2 feet clear of the ground. For vertical polarization, the loop was fed at one corner (A-B) with one-to-one balun and a quarter-wave-length Q-section made of 7'8" of RG-59/U line (75 ohms). The transmission line was RG-58/U (50 ohms). The measured s.w.r. at 21.2 mHz was 1.3. Raising the loop so that the bottom was 6 feet above the ground raised the s.w.r. to 1.8 at 21.2 mHz. The loop is directional broadside, with minor lobes in the plane of the loop. The balun and feedline are dressed along the horizontal arm back to the center of the loop, then drop down the mast to ground level.

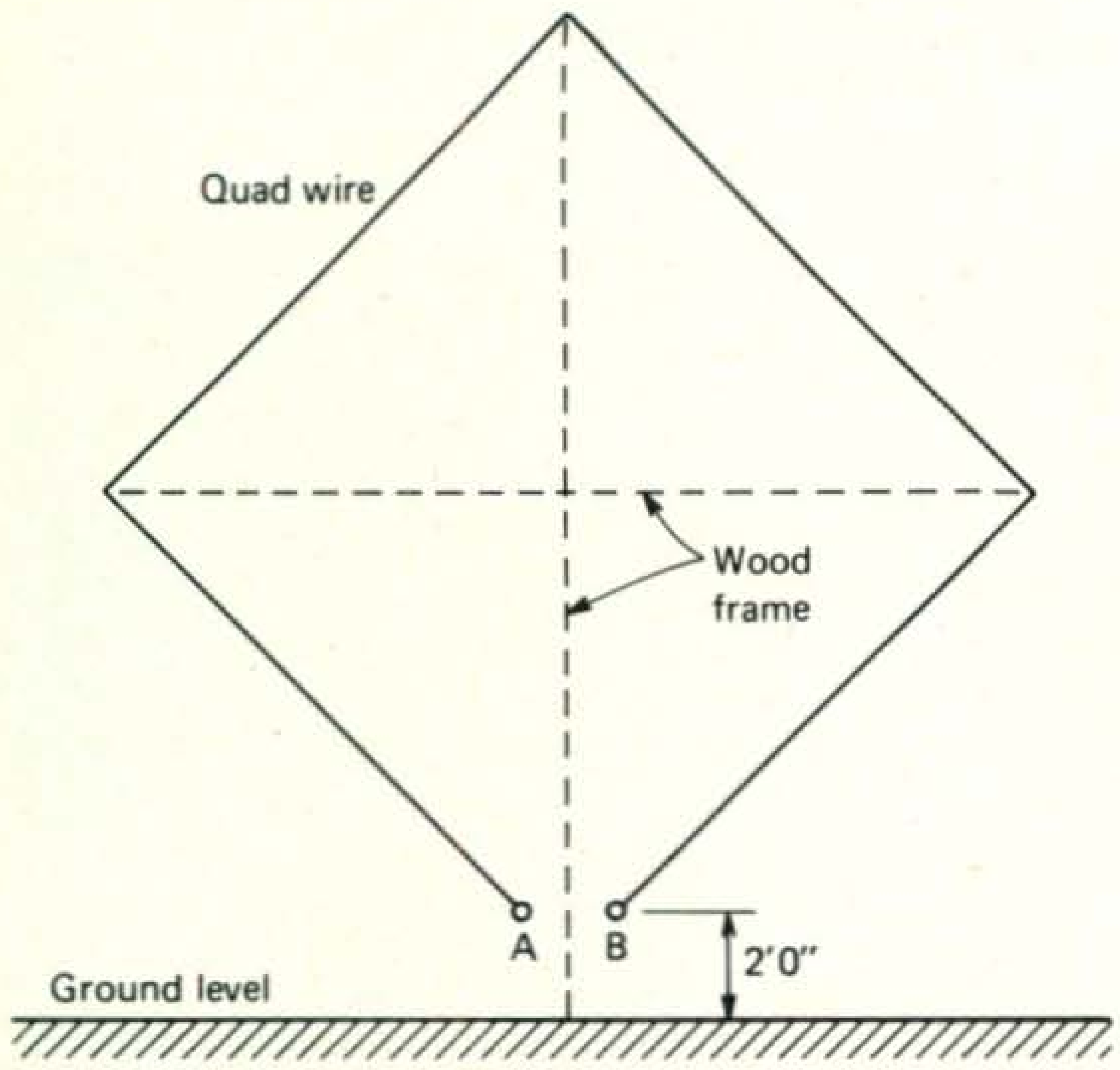


Fig. 2—The horizontally polarized loop. The loop of fig. 1 was revised to provide horizontal polarization by feeding it at the base (A-B). Dimensions of loop and matching line remain the same. The line was brought down to the ground and led away from the loop at ground level. This low loop proved to be much better than a ground plane antenna with 4 radials mounted at the same base height.

adjacent to the vertical loop are less than those encountered with a ground plane. I reasoned that I could eliminate all radials and at the same time end up with a better antenna."

"How did the Quad loop work?," asked Pendergast.

"After the loop was up, I used it for some weeks. I immediately noticed better results in that my ratio of replies to calls went up, and I was able to work appreciably more DX with less effort than before. I would estimate that I was getting better than the 3 db gain I had hoped for, as compared to the ground plane."

"Hurrah!," said Pendergast. "You have invented the better mousetrap. The ground plane is relegated to the junk box."

I ignored the thrust, and continued. "My next experiment was to change from vertical to horizontal polarization by feeding the loop at the bottom (fig. 2). It worked even better; it seemed that I could almost compete with the big boys. So I decided to dismantle the whole antenna and bring it home with me and make direct comparisons against my 3 element Yagi on a 45 foot tower. This would be the supreme test.

"And that's exactly what I did. I reassembled the loop and tested it against the beam, both for horizontal and for vertical polarization. The results were certainly very interesting."

Pendergast bounced up and down in his chair. "What happened?", he asked. "Don't tell me the loop down close to the ground was as good, or better than, your beam up 45 feet?"

I sighed. "It really was a very unscientific experiment. I checked the antennas on receiving and asked for comparative reports on transmitting. My own S-meter is calibrated at about 4 decibels per S-unit, but I couldn't tell just how the S-meter at the other end of the circuit was calibrated. In any event, I came to the conclusion that the vertically polarized loop close to the ground was about 12 db down in signal strength from the beam. That's about 3 to 4 S-units. And the loop exhibited a lot more fading on DX signals.

"Three to four S-units worse?," yelled Pendergast. "No way!"

I continued. "After these tests, I switched the loop over to horizontal polarization and ran some tests. This loop was better, markedly, but still about 10 decibels down in signal strength compared to the beam."

There was a long silence. Finally, Pendergast sighed heavily and said, "Let me get this straight. The vertically polarized loop was at least 3 db better than the ground plane and the horizontally polarized loop was better than the vertical one."

"Right," I said.

"Well, then," Pendergast continued triumphantly, "what you are saying is that the ground plane is the worst of the lot, and probably about 13 to 15 decibels *weaker* than a good beam!"

"Let's not play decibelmanship," I replied, "But that seems to be a good guess. But if the ground plane is so bad, why is it that many stations have worked plenty of DX with it? The answer, I think, is that *most of the fellows that have had success with the ground plane antenna have mounted it high in the air,* where it radiation angle and behavior are more like a vertical dipole and where the ground losses are much less. Remember, my ground plane was very close to the earth."

I rummaged through a stack of magazines on the desk. "One of the unsung heros in the vertical antenna game was VE3AAZ. He generated a computer program to determine the effect of ground loss on vertical antennas. His article is in June, 1965 issue of *QST*. I suggest you read it.

"In his computer program, working from known radiation patterns and given amounts of ground loss, VE3AAZ — among other tests — compared a horizontal dipole antenna to a vertical antenna and to a ground plane at different elevations and found that the vertical dipole, whose center was ½-wavelength above ground compared favorably with a ground plane antenna at a takeoff angle of 10 degrees, there being less than one decibel difference between the two. VE3AAZ also computed that a vertical antenna two wavelengths high had a 5 db to 8 db advantage over a ground plane antenna mounted at ground level. Finally, he computed

that a horizontal dipole at a height of 2 wavelengths had a 2.5 db advantage over a vertical antenna whose center was at the same height. Thus, *the horizontal antenna 2 wavelengths high has an advantage of 7.5 db to 10.5 db over a ground plane antenna, mounted close to the earth,* at least for a takeoff angle of 10 degrees (fig. 3).

"Of course, the gain figures vary with elevation and takeoff angle, but I picked the values I did because my beam is just about 2 wavelengths above ground.

"Now, I know my beam has a power gain of 7.5 db over a dipole. So that makes my beam 15 db to 18 db better than a ground-mounted ground plane, at least on paper. And going one step further, it looks as if my beam is about 10 db to 13 db better than the low. horizontally polarized Quad loop. And that range of figures agrees fairly well with my estimate based upon signal reports and listening tests."

Pendergast shuddered. "How can you work any DX if you give away 10 db or more to your competition?"

"Don't forget that this is a paper argument," I replied. "But the computer study of VE3AAZ does agree with what I found out the hard way. Even so, the ionosphere is a great leveler of signals.

"In the conclusion of his article, VE3AAZ says, 'there seems to be very little to be said for vertical polarization except for the non-directional feature.' He was talking about h.f., not v.h.f., of course."

"You both are certainly shooting the popular ground plane antenna down in flames," said my friend. "It sounds as if you couldn't punch your way out of a paper bag with it."

"That's part of the game," I replied. "I do know the vertical loop, close to the ground, is better than a ground plane at the same height above ground. And the horizontal loop is better than the vertical loop. The whole picture is rather confusing, but it is possible to draw some interesting conclusions from the whole exercise."

"And these conclusions are?," asked Pendergast.

"Simply this. If you are restricted to a ground plane for the h.f. bands for esthetic or other reasons, you should either get it high in the air, where it will work with a few radials, or use a half-wave vertical antenna. If the ground plane must be mounted close to the ground, because of necessity, use plenty of radials on it. Read W2FMI's series of *QST* articles on this subject.

"If you can go to a Quad loop, even though it is close to the ground, it will perform better than the ground plane antenna. Horizontal loop polarization, moreover, seems to outperform vertical polarization. It still might be a good idea to put a radial system under the loop. I feel sure it will help, especially with vertical polarization, but I haven't tried it."

"The closer to the ground, the greater the need for radials," said Pendergast.

"Apparently that's so," I responded. "I would like to hear from readers of this column who have used a ground plane or half-wave vertical on the h.f. DX bands with success. It would be interesting to see how they worked out, DX-wise."

"Are you going to give a freebie?," asked Pendergast.

[*continued on page 66*]

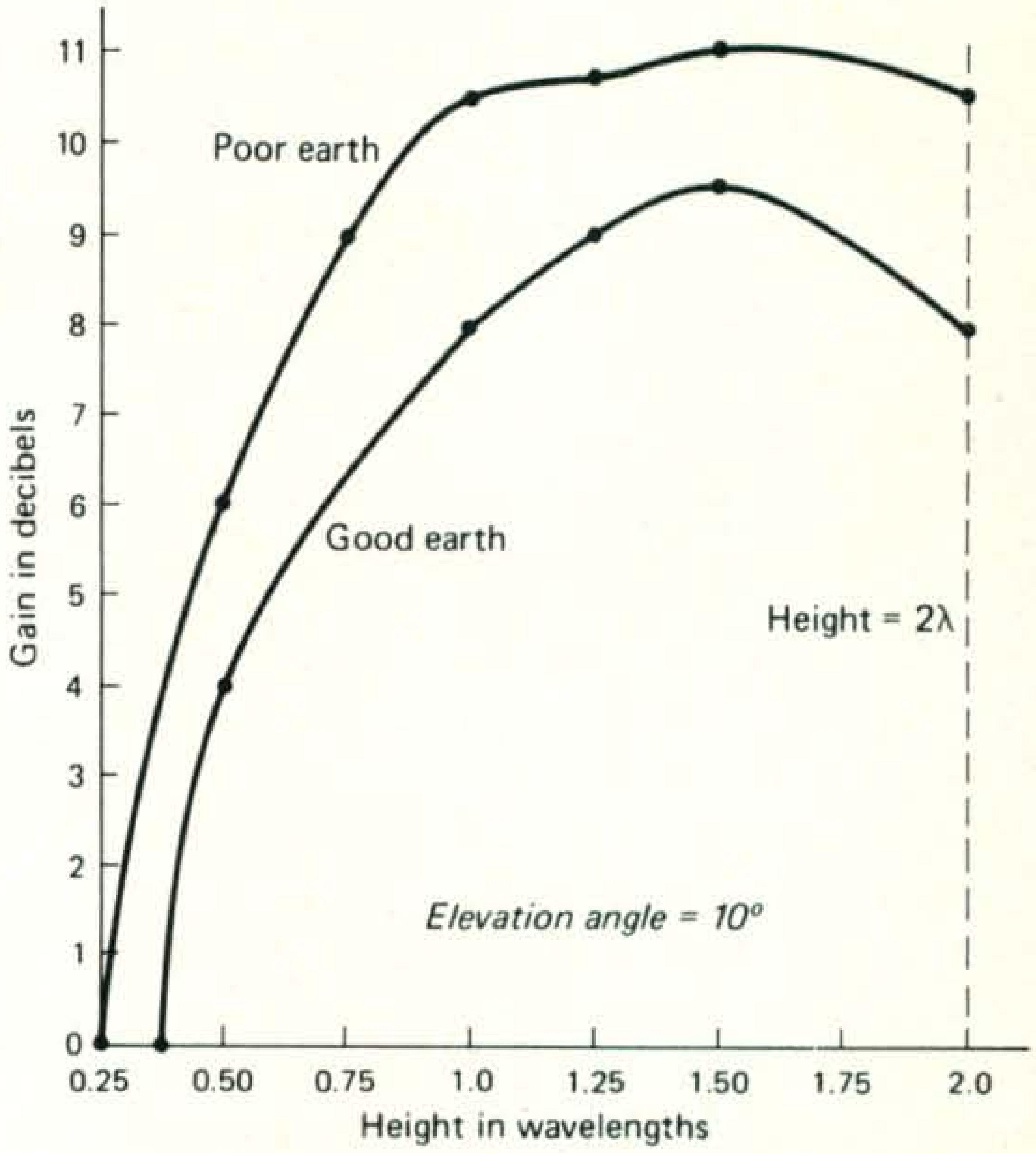
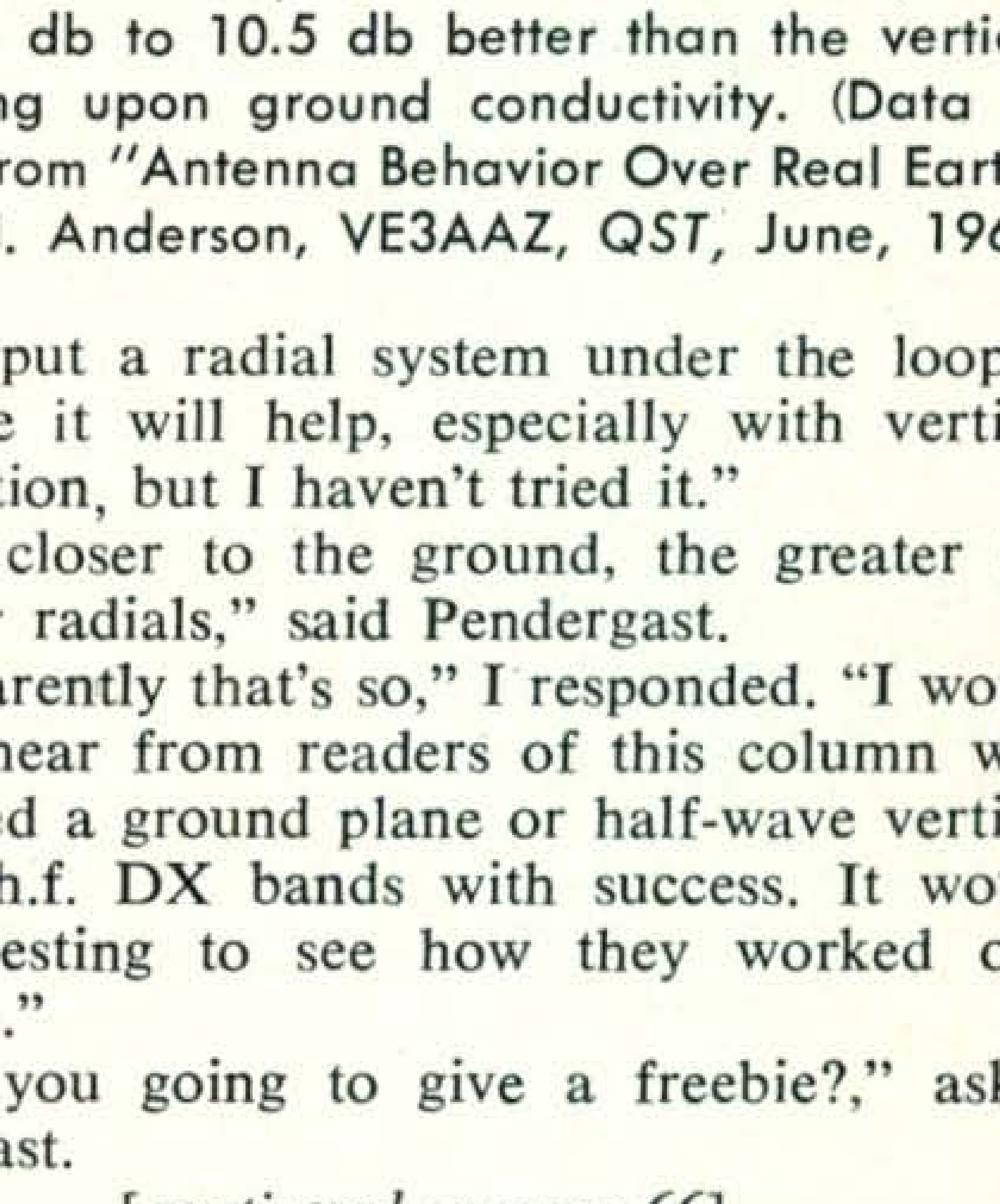


Fig. 3—Horizontal dipole outperforms ground-plane antenna. The horizontal dipole consistently provides a better signal at an elevation angle of 10 degrees above the horizontal that does a vertical dipole antenna whose center is ¼-wavelength above ground. At a height of 2 wavelengths, for example, the horizontal dipole is from 7.5 db to 10.5 db better than the vertical, depending upon ground conductivity. (Data extracted from "Antenna Behavior Over Real Earth," by W. H. Anderson, VE3AAZ, *QST*, June, 1965).

Mako
... by JA3OVM



Mako meets a smooth-talking operator.

Antennas [*from page 50*]

"Why not?," I replied. "For every contribution I receive and put in the column, I'll be pleased to send the contributor a complimentary *Handbook* of mine."

Pendergast stretched and yawned. He started toward the door of the shack. "Glad I don't have to worry about ground planes and low, low loops. My six element Yagi on the 110 foot tower really does the job."

"Yes, and your Pachenko machine helps too, doesn't it?," I rejoined. But Pendergast was on his way and didn't hear my final remark. ■

antennas

BY WILLIAM I. ORR,* W6SAI

PENDERGAST opened the door of the shack. A scimitar of cold air slashed across his face and a flurry of snow sifted into the room. He closed the door hurriedly and said, "It's a cold night on the moor! Glad I don't have to shinny up a tower to work on an antenna tonight." Sensing no reply, he looked over at me and noted, "Still digging through the mail? Anything interesting?"

I dropped the pile of mail into my lap. "Never underestimate the ingenuity of a radio amateur," I replied. "Lots of hams are interested in the so-called "invisible" antennas because they have problems getting a sky-wire in the air." I paused, and pulled a letter out of the pile.

"Here's a great letter from John Milford, DA1JM. He's at a military base in Germany. Listen to his problem and how he solved it . . . 'I live on base and the houses are nearly identical on each and every base in Germany. They are 3 or 4 stories high, with either a flat or peaked roof. Until recently, we had a flat roof with a 30 foot tower atop it. The tower was capped off with a 2 element Quad built from the data in your "Cubical Quad Antennas" handbook[1].

'The flat roof is being replaced with a peaked roof, because of snow loading, I guess, and the antenna had to come down. And it can't go back up, because Uncle Sam doesn't want any antennas sticking out of the new roofs. All the roofs in the U.S. bases are being replaced with new, peaked roofs! Worse, still, the new roofs are all-metal construction, eliminating the possibility of an antenna under the roof.

'To get around this problem, I put up a vertical dipole on the side of the building, with a reflector. A simple two element beam, held to the vertical side of the wood building by small standoff insulators! In order to disguise the antenna, insulated wire was used with the same color jacket as the building color. A balun was used on the driven element and I painted it the same color as the building. The coax was run perpendicular to the driven element, half the distance to the reflector, and then straight down to the shack window. An old military rule of camouflage is that in a jungle or wooded area curved lines are best hidden, but in the open straight lines draw least attention! The finished antenna was well disguised and would be unnoticed if you did not know it was there.

'The beam worked so well I added 10 and 15 meter elements in a V-formation, at about 150 degrees to the 20 meter elements (fig. 1).'

"Pretty clever," said Pendergast. "Does DA1-JM say how the beam works out?"

I continued reading, "The antenna works well, though not as well as the Quad atop the tower. It seems to have good forward gain and a front-to-back ratio of about 15 db. The s.w.r. is quite low on all bands, running about 1.3 at resonance."

"Well," said Pendergast, "That proves it is pretty hard to keep a sharp ham off the air."

"Correct," I replied. "And here's a novel antenna scheme from Bob, WA2PCL. He can't put up a ham antenna, either, but all the apartments in his area have wash lines running out to poles in the back yard. Silly, isn't it? A wash line is OK, but a ham antenna on the roof is *verboten!*

"So Bob made the wash line into an antenna

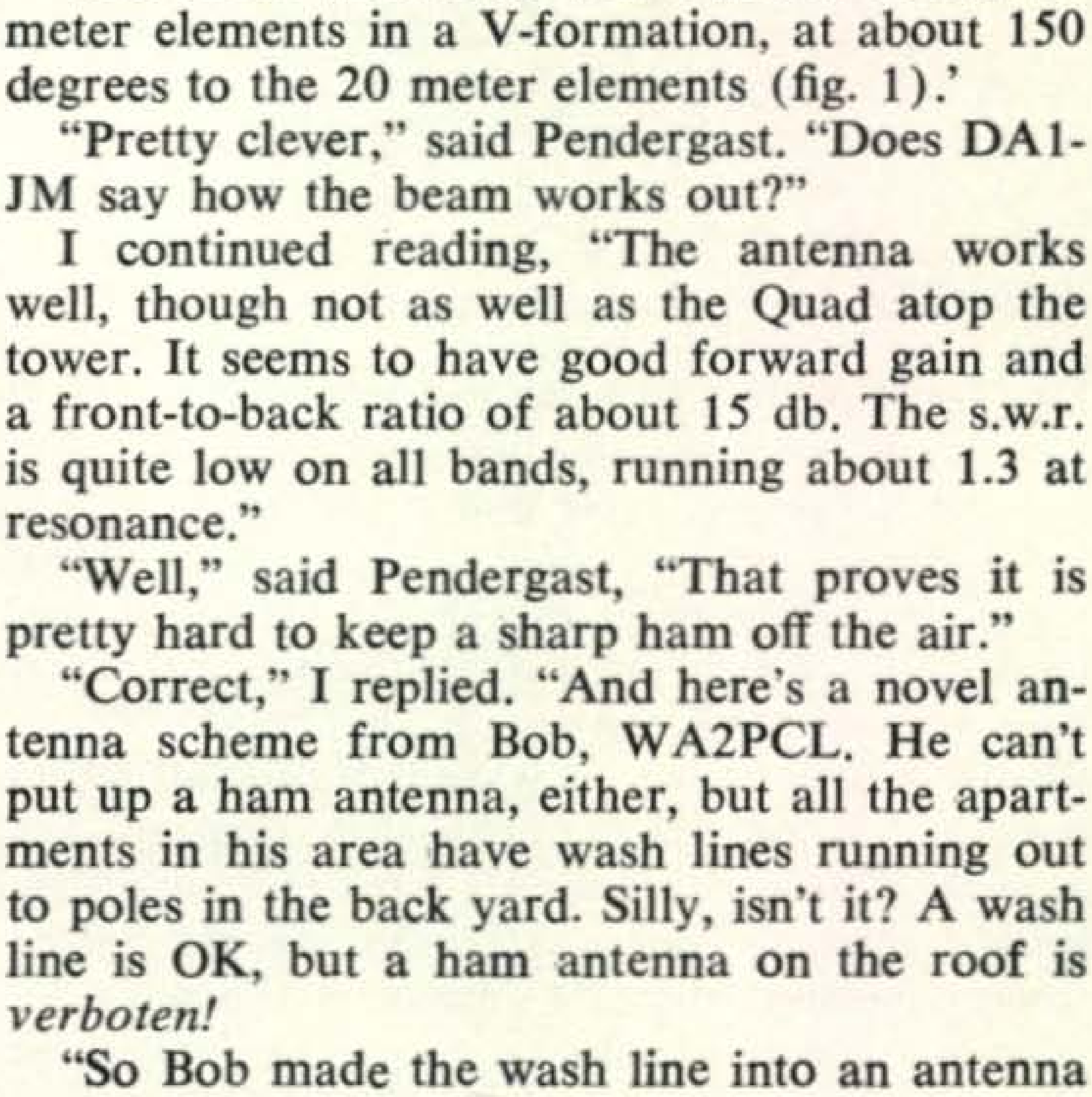


Fig. 1—DA1JM's "invisible" beam antenna in a vertical position on the wall of a 3 story wood frame apartment building. Beam dimensions are normal. The multiple reflectors are connected at the mid-point. The elements are constructed of insulated wire, painted to match the building and are held in position with small standoff insulators. The coaxial line is brought in a window. The beam is only one-inch away from the wood siding.

*48 Campbell Lane, Menlo Park, CA 94025.

[1] "All About Cubical Quad Antennas," Orr, Radio Publications, Wilton, Conn. 06897 ($3.95 plus 25¢ postage).

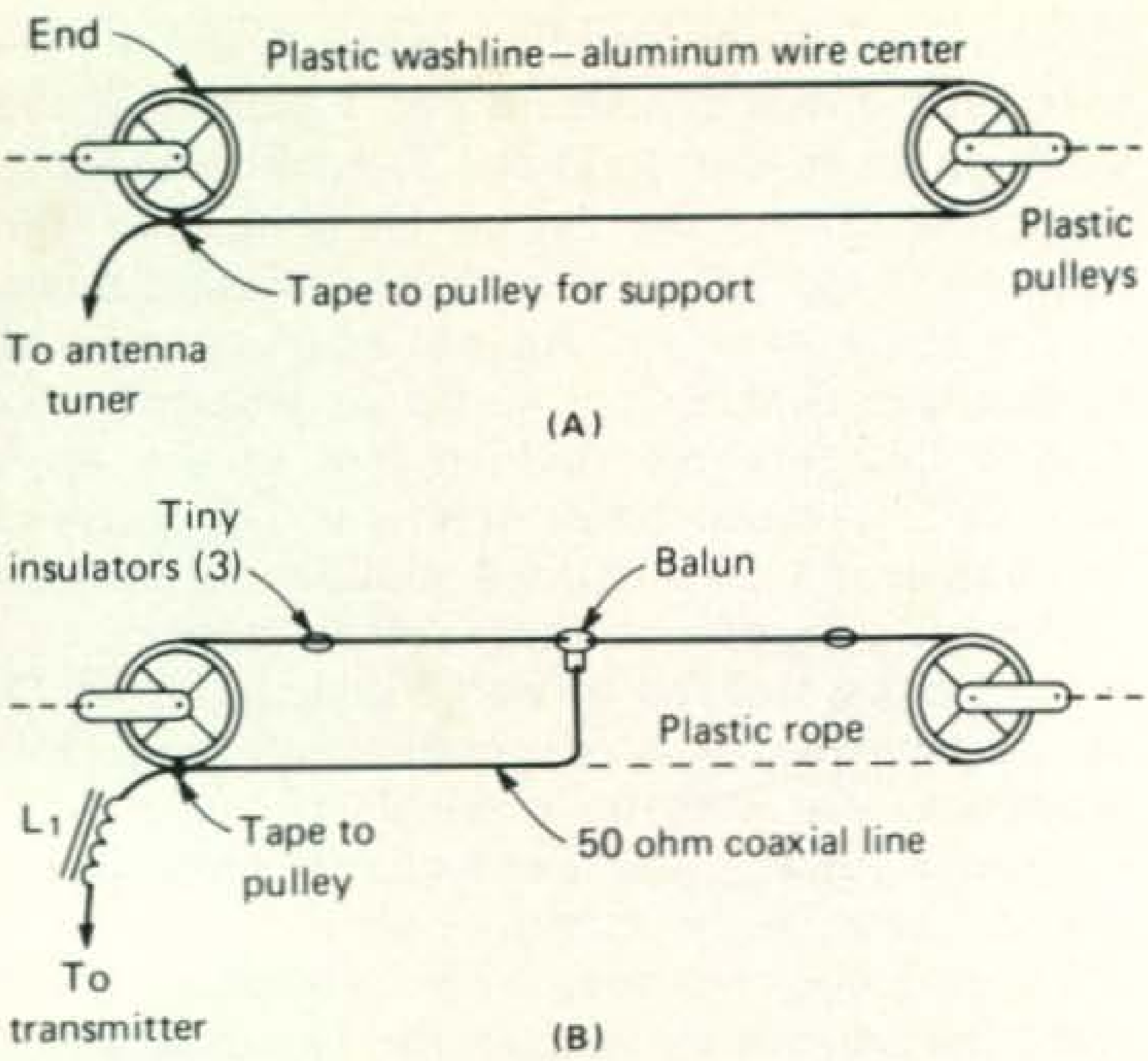


Fig. 2—WA2PCL's antenna is a washout! (A) Long wire antenna running back and forth between two plastic pulleys resembles a clothes line. End-fed antenna tuner is used in conjunction with a radial ground wire in the shack. (B) Dipole antenna with coaxial feed. Outer conductor of coaxial line should connect to left-hand side of dipole. Coaxial line is wrapped around ferrite core (L_1) to provide r.f. choke to suppress line currents. Choke consists of 3 turns of coaxial line passed through Indiana General CF-117 ferrite toroid, making a coil 4 inches in diameter for RG-58/U line. For data on ferrite, write Indiana General Corp., Crow Mills Rd., Keasby, NJ 08832. Core is Q-1 material, 1.875" diameter.

(fig. 2). He's tried a dipole and also an end-fed antenna, with a simple antenna tuner. Both ideas work out well and he's on the air."

"Not bad," said Pendergast. "I remember in New York City, there were big areas of 4 story apartments with clothes lines draped all over the rear yard. No reason why one of them wouldn't do double duty."

"Well, K4MD takes the prize," I replied. "He's stuck with an antenna problem, and one day he heard a ham in Pennsylvania describe his antenna. The fellow was living in an apartment house which prohibited the erection of *any* antennas. So he connected his antenna tuner to the aluminum window frame of his room and used that for an antenna.

"K4MD tried this out. He ran a piece of wire about 2 feet long from his rig to the aluminum window and used a quarter-wave ground radial in the shack, running along the floor. He used the window frame antenna on 40 meters.

"K4MD had an end-fed wire outside to compare the window antenna against, and found out it was about one S point weaker than the end-fed wire. He used it on some schedules and it worked fine. Admittedly, the window frame antenna is no DX antenna, but it does work and would be a boon to a cliff dweller who can't erect an outside antenna. Too bad we don't know who the Pennsylvania ham is who gave the idea to K4MD."

Pendergast scratched his head. "Glad I don't have antenna problems," he muttered.

"Sometimes you can't help yourself," I replied. "Here's a great letter from W9IZ with a report on an attic antenna. Some years ago Bill put up a 2 element beam on a tower. He moved about a mile, and took down the beam. Before he got it up again, his daughter moved to Boston and he wanted to work a phone patch with her.

"Since it was the dead of winter, he didn't want to put the old tower up, so Bill put his 2 element beam up in the attic of his home. This was about 25 feet high, I imagine.

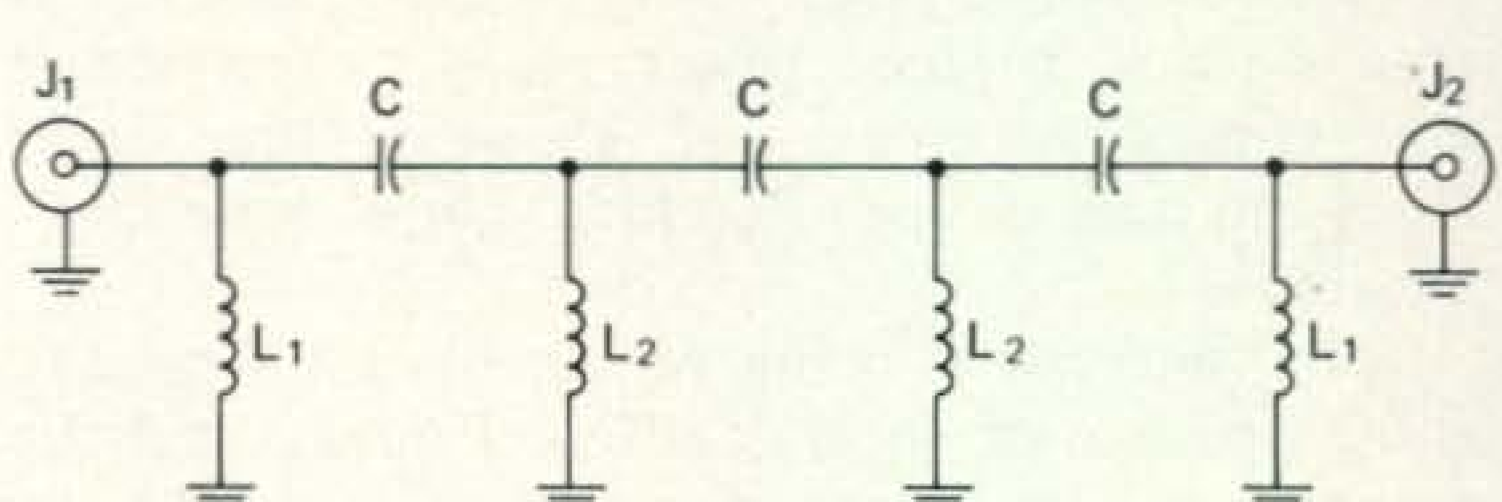
"Bill says, 'I cut the beam up into 4 or 5 pieces, maneuvered it up into the attic through a closet ceiling access cut-out, reassembled it and—with a few pieces of 1 × 2 wood—hung it on the rafters. I then took it all down and reversed the elements and put it back again, having found I had aimed it at California instead of Massachusetts!

'A word of caution! When installing an attic antenna, *do not* grab hold of a rafter and a wasp nest at the same time. This could cause one to step through a bedroom ceiling, incurring the displeasure of the XYL, etc.

'Since I had used the same beam before, I had somewhat of an idea of what to expect in the way of results. It really beams! And I've been using it for seven years, and have never bothered to put the old tower up again!' "

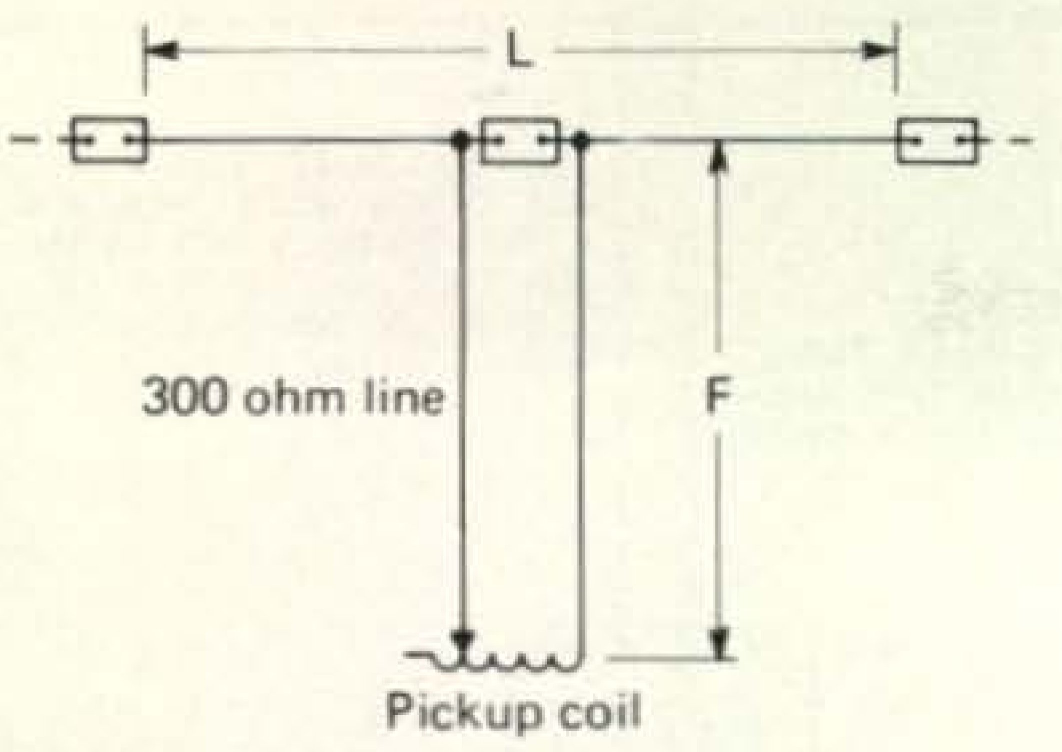
"That's really great," said Pendergast. I always wondered what snow would do when an indoor antenna was used."

"I once read an article about the hams at the



Band	80	40	20	15	10
L_1 (μH)	3.2	1.6	0.8	0.42	0.325
L_2 (μH)	1.6	0.8	0.4	0.21	0.17
C (pf)	600	300	150	80	62
f_{CO} (mHz)	2.5	5.0	10.0	18.0	25.0

Fig. 3—Low-pass filters for receiver protection. Each filter protects from signals lower in frequency than the designated band. Capacitors are silver mica, and inductors may be high-Q receiving type coils with movable powdered iron slug. Filter is built in aluminum box with coils arranged for minimum coupling between them.



Antenna length, L	136	275.5	67	103
Feeder length, F	66	99	65	82.5
Bands	80–40–20	160 thru 20	40–20–10	80–40–20
Nominal input impedance	1200Ω	1200Ω except 75Ω on 40M	75Ω = 40M 1200Ω = 20, 10M	1200Ω

Fig. 4—Original Collins "multiband" antenna, the grandfather of the modern G5RV antenna. The antenna is center-fed, with flat-top and feeder length chosen to provide either a 1200 or 75 ohm termination at the transmitter on various bands. The 300 ohm line was made of aluminum tubing. Antenna was described in the 1937 issue of the *Radio Handbook* as well as the ARRL *Handbook*. Made with modern, open-wire 300 ohm line, and used with an antenna tuner, the Collins antenna serves as a good multiband antenna today. 300 ohm ribbon line may be used for low power, if feeders are cut to 82 percent of lengths given in table.

Antarctic bases who laid their antennas right on the snow," I replied. "It seems to be a good insulator."

Pendergast looked out of the shack window. The snow, which had been falling steadily, had now stopped, and there were only small flurries in a clearing sky. He sighed.

"It may seem silly at this time of year to think of Field Day", he said, "But I'm going to try to get things organized early this year so it won't be a last minute panic. One of the things that would help, I think, is a set of low pass filters for each band. When you go multi-operator, a real problem is receiver overload, especially from a nearby transmitter on a lower band. Have any ideas?"

"A simple low pass filter may help," I replied. "For example, a design like this, built into a small aluminum box would attenuate low frequency signals, provided the signals did not sneak around the filter and get directly into the receiver (fig. 3). For example, the 80 meter filter attenuates all signals below 2.5 mHz, which includes the 160 meter band. The 40 meter filter cuts off at 5 mHz, knocking out the 80 and 160 meter bands. The 20 meter filter cuts off at 10 mHz, knocking out the 40, 80 and 160 meter bands, and so on. They can be built using little, high-Q coils and will fit in a very small box."

"Thank you," said Pendergast. "I'll copy the information in my little black book." He paused. "Before I push off into the snow and sleet, why don't we have a little discussion about the G5RV antenna. I work a lot of Aussies and G's and many of them use the G5RV, but they don't tell what it is on their QSL card. Do *you* know what a G5RV antenna is?"

"Well, I think so," I replied. "Basically, it is a center-fed, multi-band antenna. Sometimes it uses an antenna tuner, and sometimes not. If my memory is correct, this design was first publicized by Collins Radio Company in 1937 as the 'Collins Multiband Antenna' (fig. 4). The original description was in the 1937 ARRL *Handbook*, and also the 1937 *Radio Handbook*. Antenna dimensions were chosen so that when a 300 ohm feedline was used, the impedance at the bottom end of the line was either a low, or high value (75 ohms or 1200 ohms, if my memory is correct). Then, either a series-tuned or parallel-tuned network was used to couple the antenna system to the transmitter.

"The original antenna was written up in the 1936 issue of the *Collins Signal* magazine, as an adjunct to the Collins 30FXB transmitter. The 300 ohm line was constructed of ¼-inch diameter aluminum tubes spaced 1½ inches, center-to-center.

"As you can see from the illustration, several lengths of flat-top and feeder were available, and the end of the feedline was either coupled to the tank coil of the transmitter via high voltage capacitors, or a tapped pickup coil was used.

"The G5RV antenna is the 103 foot version, shortened to 102 feet for some obscure reason. Either open-wire line, or 300 ohm ribbon line may be used (fig. 5). This information is from the RSGB *Radio Communication Handbook*, 4th edition—a darned good reference work, by the way.

"The G5RV antenna can also be used with a 75 ohm twin-lead feeder. In any event, it is a refined version of the original Collins antenna, transplanted to England."

Pendergast smiled. "It seems a lot of antennas are named after popular DX stations that use them. The VS1AA antenna is the old single-wire-fed antenna called the *Windom*. That, of course, is named after 'Windy,' W8GZ, who popularized it. And don't forget the popular W8JK beam, too." He began to tug on a heavy sweater and prepared to leave.

CQ Country Chart
A two color, wall-sized country chart is available on poster stock and in large type for only $1.25 per copy postpaid. Address request to: CQ DX Country Chart, CQ Magazine, 14 Vanderventer Ave., Port Washington, N.Y. 11050.

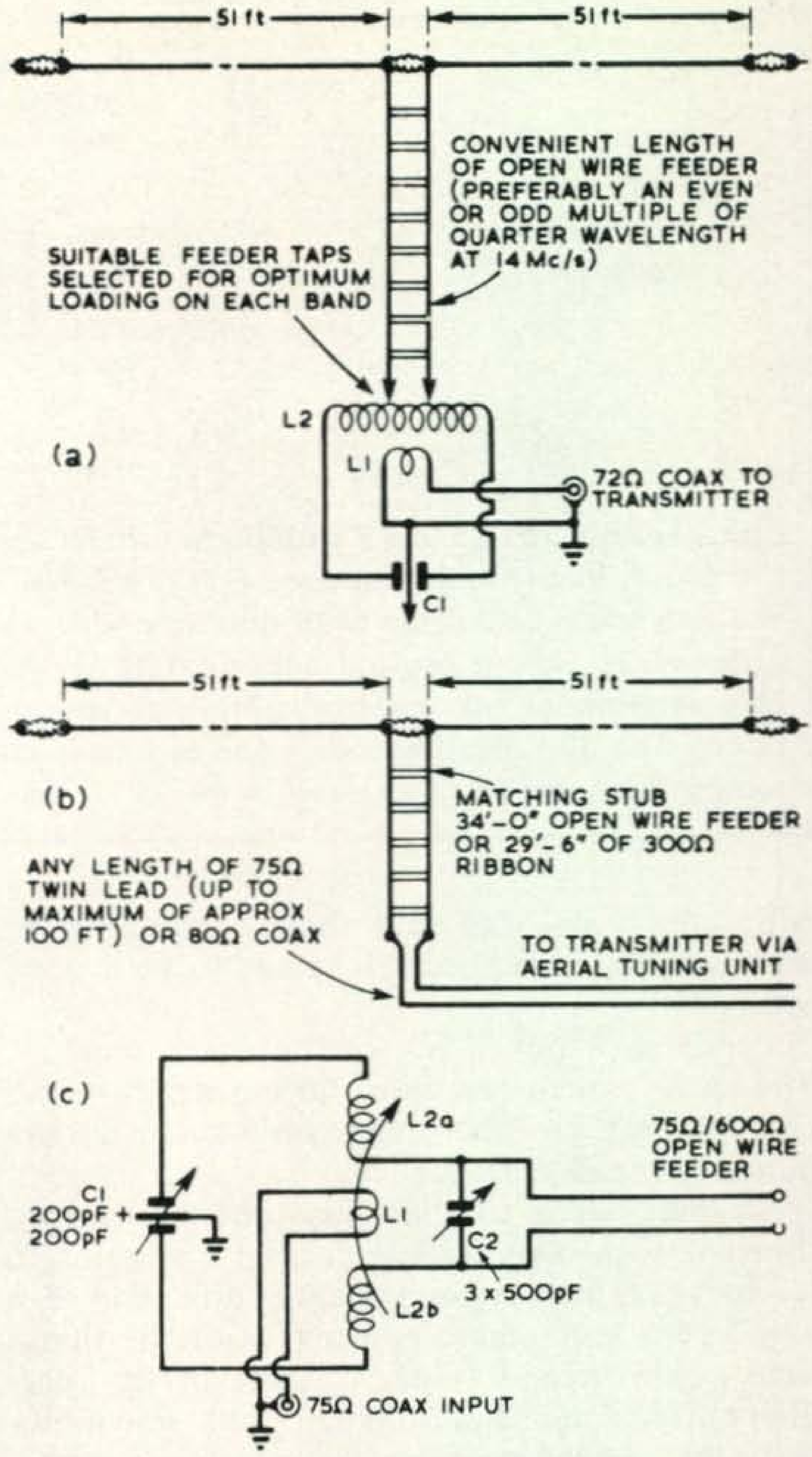


Fig. 5—Modern G5RV antenna, today's version of a 1937 idea. (A) Antenna tuner used with G5RV for multiband operation. (B) G5RV fed with matching stub and low impedance transmission line. (C) Universal antenna tuner. Impedance transformation ratio depends upon capacitance ratio of C_1 and C_2. Coils L_1 and L_2 are standard tuner coils. (Drawing courtesy of RSGB and *Radio Communication Handbook).*

"Season's Greetings and best wishes for 1975," he said with a smile. "What do you predict for amateur radio, antenna-wise, for the coming year?"

"Well, as Bob Booth, W3PS, says, 'It is difficult to prophetize, especially with respect to the future.' However, my guess is that there will be increased interest in log-periodic and log-periodic dipole arrays for the h.f. bands, increased interest in low frequency antennas for 80 and 160 meters—as the sunspot cycle drops—and more interest in moonbounce and moonbounce antennas. That guess covers a broad enough field so I can't be 100 percent wrong!"

Pendergast opened the door and a flurry of snow slid into the room. "Best Holiday Greetings," I said, "And may all your DX stations come back to you in 1975." ■

antennas

BY WILLIAM I. ORR,* W6SAI

"Baluns," said Pendergast emphatically, gently pounding the table so that the bottle would not overturn. "Baluns are the name of the game."

I held my glass of *Chateau Yquem '64* up toward the window, letting the golden, afternoon sunlight illuminate the liquid.

"Good body and color," I said. "Notice the aroma. A superlative wine in a good year."

*48 Campbell Lane, Menlo Park, CA 94025.

"You are not listening," replied Pendergast. "Hardcore just put a balun on his tri-band beam. Claims it improved his front-to-back ratio and gave him a good S-unit more signal strength. What do you think of that?"

I put the glass on the table. "Poor Hardcore," I replied. "It seems as if he has re-invented the wheel. Baluns have been around for a long time."

Pendergast figeted impatiently. "Well, his tri-band beam was fed directly with a 50 ohm coaxial line. Bound to be plenty of mismatch. He never could get a decent s.w.r. figure—."

"Now, hold it," I said. "I'm tired of hearing you sound off about s.w.r. and Hardcore's ability to work DX. And that goes for baluns, too. Believe me, baluns, speech compressors and multi-element high frequency beams are joining the status of horsepower in cars, antenna gain and receiver sensitivity as far as the sales pitch is concerned.

"Let's get to the point—baluns, in this case! A balun is nothing more or less than an electrical transformer for converting a balanced electrical system to an unbalanced one, or vice-versa. By a balanced system, I mean a 2-conductor system with both conductors electrically

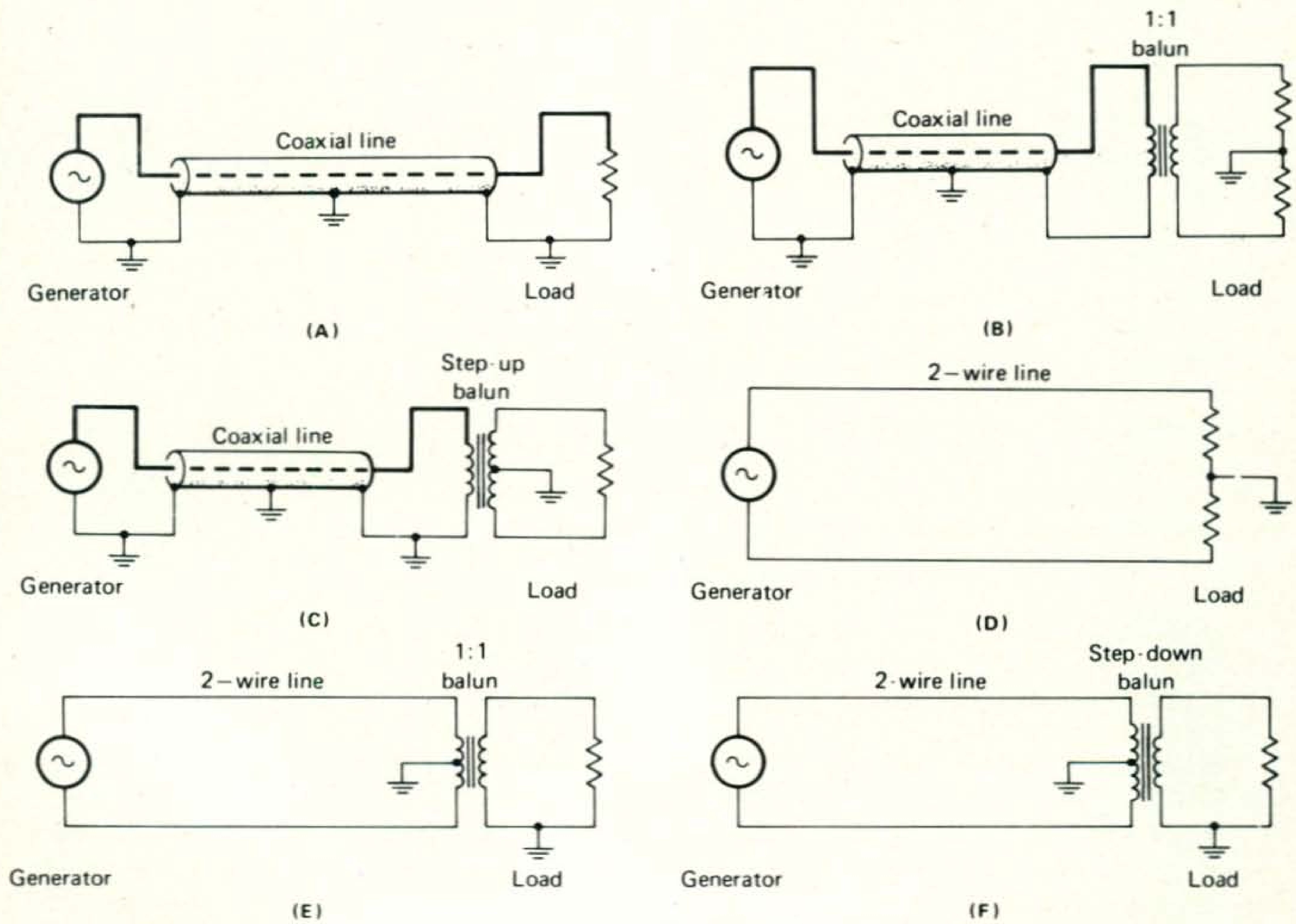


Fig. 1—The simple balun transformer. (A) Unbalanced generator feeds unbalanced load via coaxial line. (B) Unbalanced generator feeds balanced load through coaxial line and balun transformer. The secondary of the transformer may be center-tapped and returned to ground. (C) Unbalanced generator feeds high impedance load through coaxial line and step-up balun. In this example, secondary of balun is center-tapped. (D) Balanced generator feeds balanced load through 2-wire, balanced line. (E) Balanced generator feeds unbalanced load through 2-wire balanced line and balun transformer. (F) Balanced generator feeds low impedanced, unbalanced load through a balun and 2-wire, balanced line.

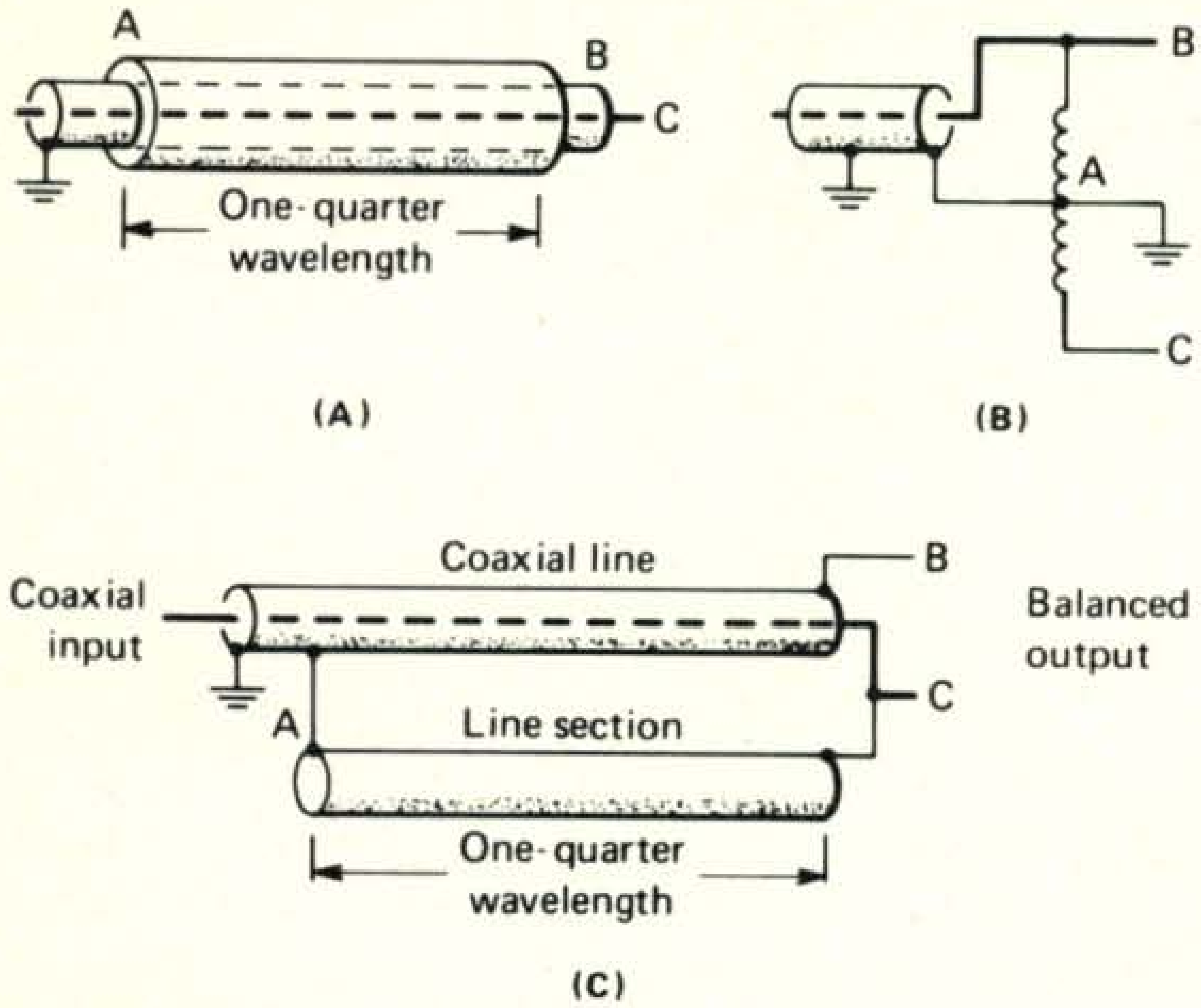


Fig. 2—Unbalanced coaxial line provides a balanced termination at points B-C by introducing a high impedance between the outer conductor of the coaxial line and ground by means of a quarter-wavelength sleeve (A). The equivalent electrical circuit is shown in (B). (C) shows a linear version of the coaxial balun utilizing a quarter-wavelength long transformer section. Point A is at ground potential and points B-C are electrically balanced to ground. This linear balun provides no impedance transformation and is the prototype for the coil balun shown in fig. 4. The line section has the same diameter as the coaxial line and forms a 2-wire transformer with an unbalanced input and balanced output.

balanced to ground. And by an unbalanced system, I mean a 2-conductor system with one conductor at ground potential (fig. 1). Sometimes an impedance transformation is accomplished in the balun, but not always.

"Quite simply, it is possible to transform from an unbalanced system to a balanced system by merely introducing a high impedance between the outer conductor of the unbalanced coaxial line and ground. The simplest example of this is the coaxial sleeve (fig. 2). This balun is quite frequency sensitive but is usable over a single amateur band. There's no impedance transformation and the balanced output is at the same impedance level as the unbalanced input. A modified version of this uses a parallel-line construction instead of a coaxial construction."

"Yes, yes," said Pendergast impatiently. "That's old stuff. But how about the newer coaxial coil baluns and the ferrite core baluns?"

"Look at this," I replied, sketching fig. 3. "This is the balun of fig. 2(C) redrawn in a straight line. Notice that a common ground point is required for the end of the right-hand balun section and the shield of the transmission line, which forms the left-hand section. Now, if you just roll this up into a coil—."

"You have a coaxial coil balun," interrupted Pendergast. "Now, I see the similarity between the two designs! And the bandwidth is greater with the coiled balun than with the linear balun, is it not?"

"Correct," I replied. "The leakage reactance and turn-to-turn capacitance determine the upper frequency limit (30 MHz) and the inductance of the coils determines the lower frequency limit (6 MHz). I described a balun of this type, and how to build it, in the February, 1966 issue of *CQ*. The article was before its time, because it caused not a ripple of excitement. However a few years later, the letters started to come in, and the coaxial balun finally came into its own.

"If you don't have a 1966 *CQ*, here's a quick summary of the design. Physically, the balun looks like fig. 4(A). The coil has an inner diameter of about 6½ inches for RG-8A/U coaxial line. I wound my balun on a hunk of PVC plastic pipe I got at a plumbing supply shop. The balun consists of 9 turns. The far end of the coil is shorted, inner-to-outer conductor, and the bottom end is the 50 ohm unbalanced feed point. The coil is tapped at the exact center for the balanced output connections, which attach to the driven dipole element of the antenna. Finally, a flexible copper strap-jumper connects the top end of the coil to the coax outer conductor at the fed-end of the coil (A). It is as simple as that."

I noticed Pendergast had taken out his notebook and was scribbling furiously.

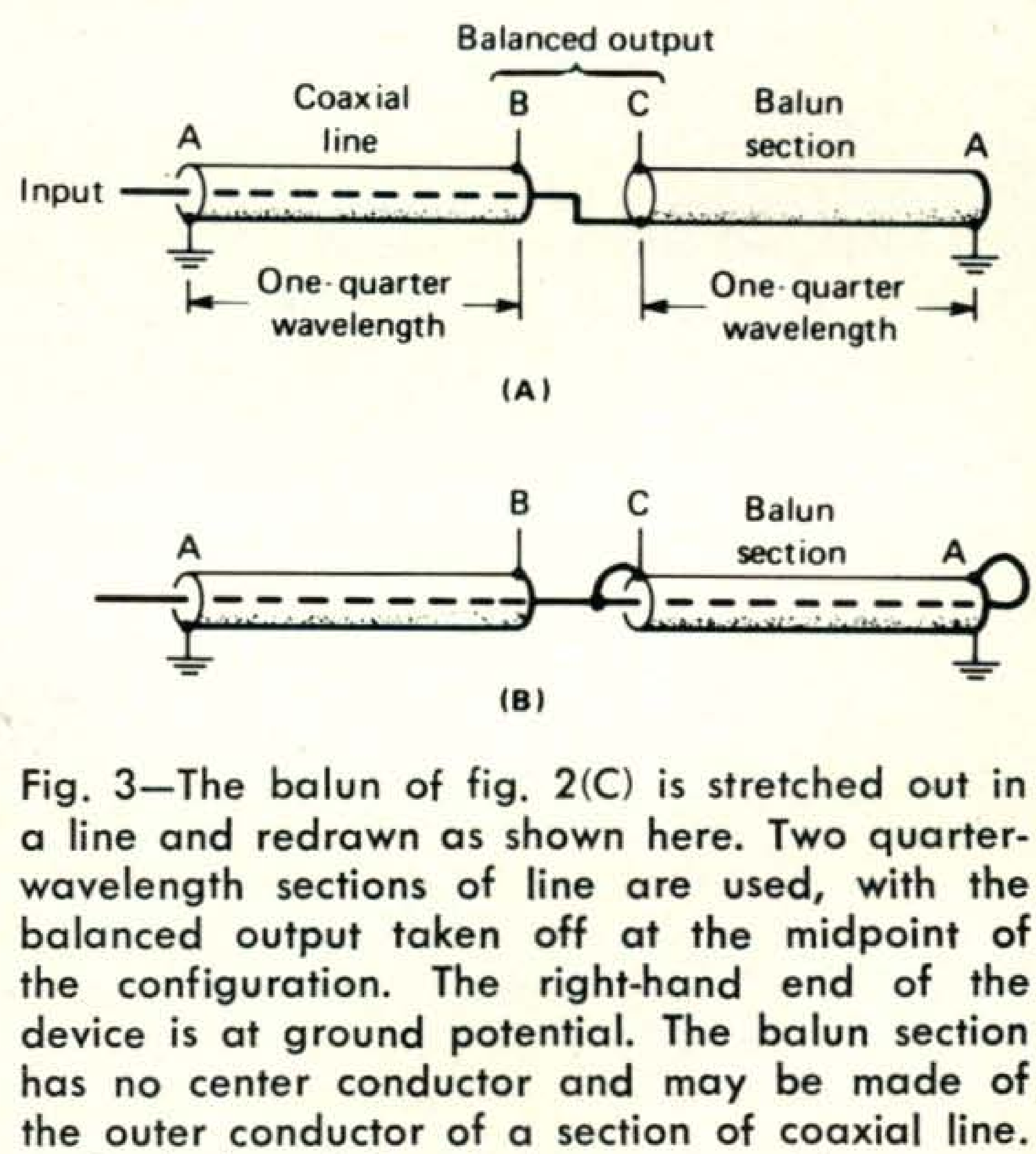
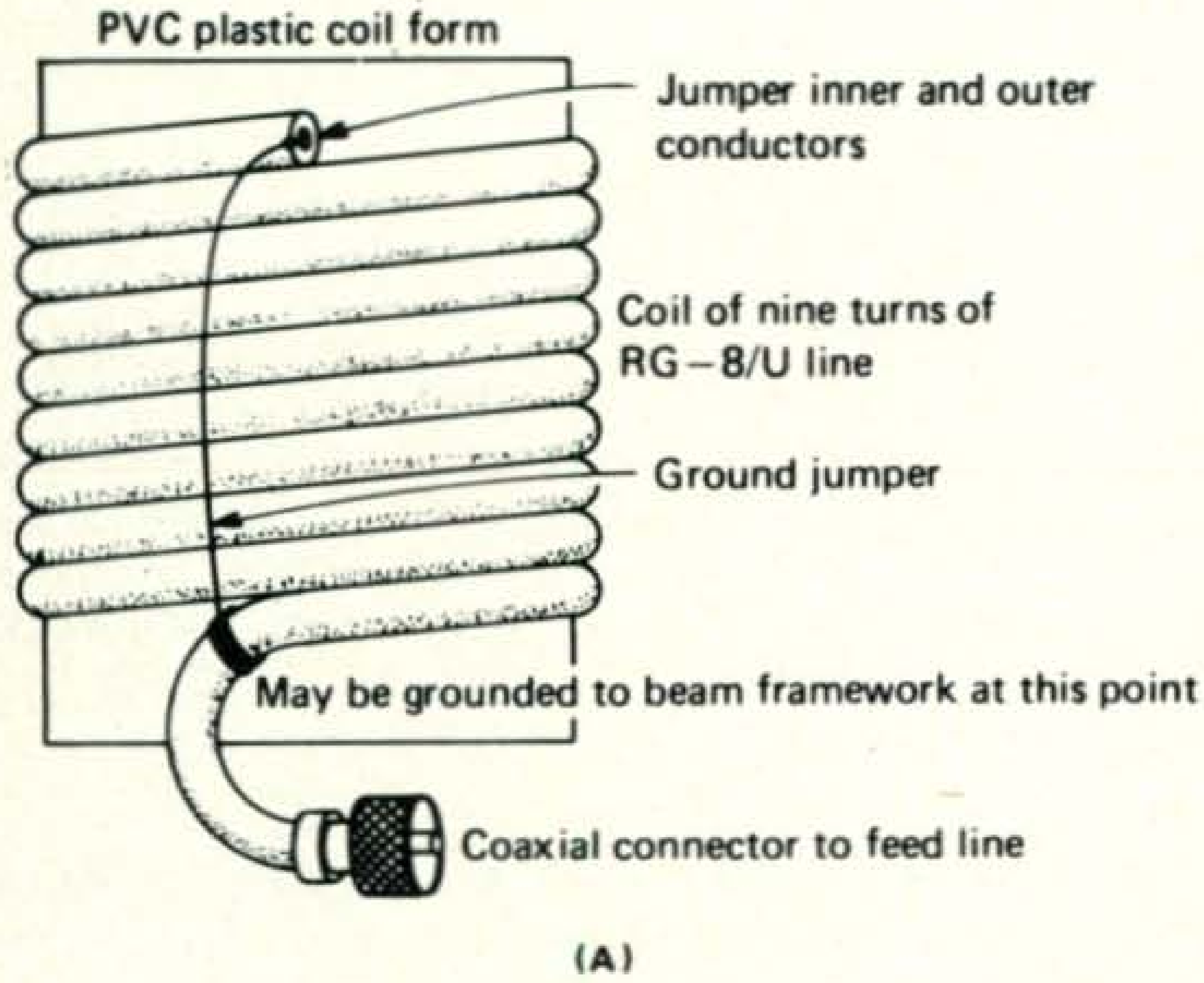


Fig. 3—The balun of fig. 2(C) is stretched out in a line and redrawn as shown here. Two quarter-wavelength sections of line are used, with the balanced output taken off at the midpoint of the configuration. The right-hand end of the device is at ground potential. The balun section has no center conductor and may be made of the outer conductor of a section of coaxial line. In the balun of fig. 4, the outer and inner conductors of the line are shorted together for ease in construction and to make the unit more rugged, but the inner conductor of the balun section contributes nothing to the action of the device. (B) shows the electrical equivalent of the balun of fig. 4, with the shorted balun section.



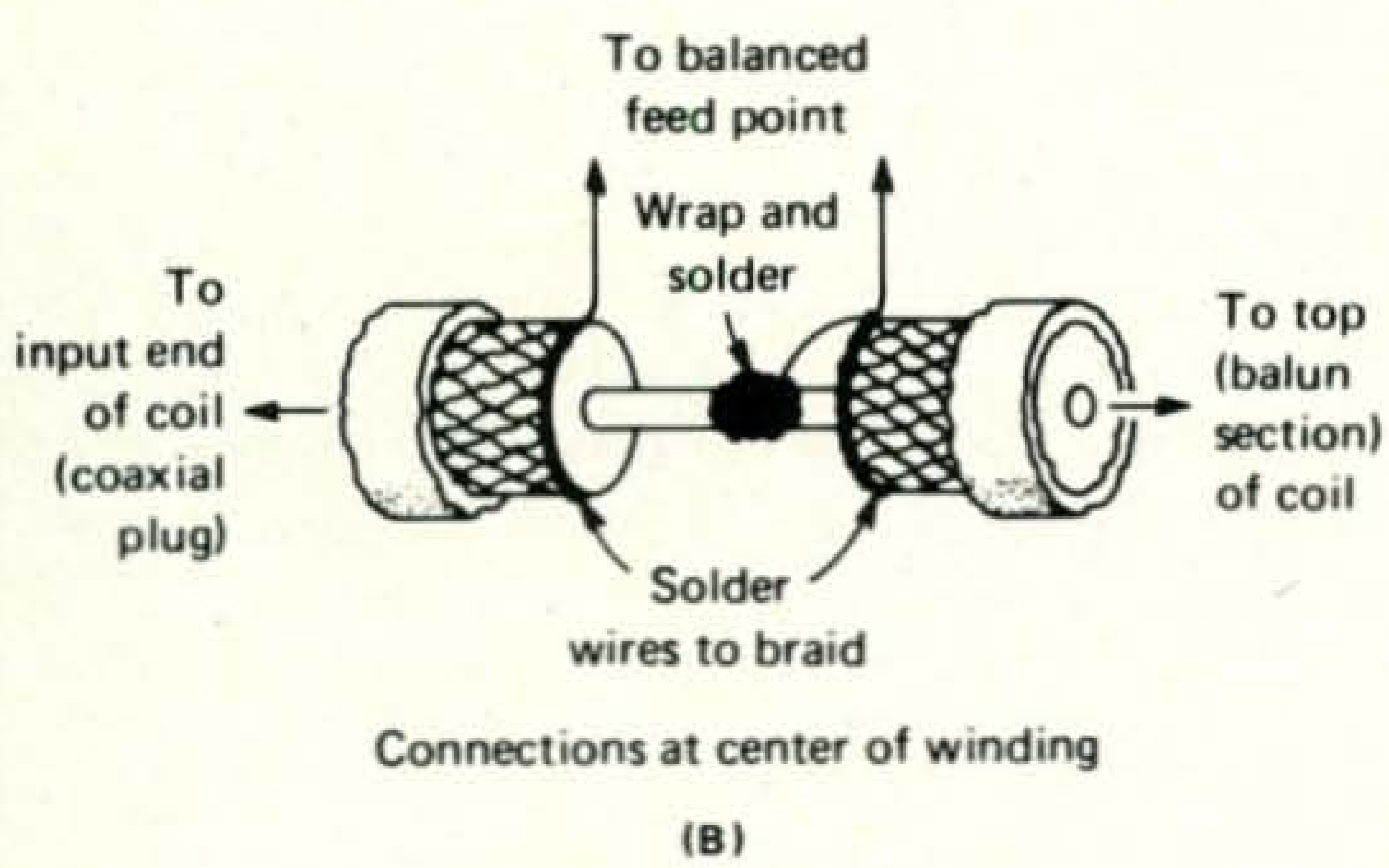


Fig. 4—(A). The coaxial coil balun is made up of nine turns of 50 ohm line wound on a form 6½ inches in diameter. In comparison with fig. 3(B), the balun section is the top portion of the winding. (B). The connections at the center of the winding are on the opposite side of the coil from the end connections and are not shown in (A). Additional information on this balun design is shown in the Feb., 1966 issue of CQ and also in the 19th edition of the *Radio Handbook*, published by Editors & Engineers division of Howard Sams, Inc.

"Tell me about the center connections," he asked.

"Start off with a piece of coaxial line about 16′ 6″ long. This will work for a coil having an inner diameter of 6½″ to 6¾″, with an inch or two of cable left over at the ends. Wind a 9 turn coil, closely spaced, and mark the mid-point, which is 4½ turns from either end. Unwind the coil so you can work with the coaxial cable more easily. Use a sharp knife and remove the vinyl outer jacket about an inch on each side of the center mark. Next, cut the braided outer conductor of the line at the center point and trim the braid back until about ½-inch is left on each side of the center point. Don't touch the center conductor or inner insulation at this stage of the game (fig. 4(B). Now, using some #14 tinned wire, wrap it around the braid at each exposed point, making terminating connections. The end of the coil which is to be shorted has two leads connected to the braid, the other end of the coil, which is the input end, has one lead attached to the braid."

"Gotcha," said Pendergast, making a large drawing in his notebook.

"Just so you won't get mixed up, better short out the far end of the coil at this point. Trim the vinyl jacket back, loosen the braid a bit and snip off a quarter-inch of the inner insulation. Twist the outer braid about the exposed inner conductor and solder the two together.

"Now you can rewind the coaxial cable on the coil form and fasten it in place with heavy twine passed through holes drilled in the form. Remember the input end of the coil has two leads connected to the shield at the center point? Well, one lead is for connection to the antenna, and the other lead is soldered to the center conductor at this point. Just remove a tiny slug of insulation from the center conductor to make the connection.

"The last step is to connect a grounding jumper from the shorted, top end of the coil back to the outer braid at the input end of the coil. I used a length of ½-inch wide copper strap scrounged from the junk box. This is the common ground point (A) and a bracket may be attached to the copper strap to mount the balun to the antenna framework if you wish.

"As a final point, you can place a coaxial plug on the input end of the balun to make a quick-disconnect joint."

"The balun goes right up at the antenna," said Pendergast.

"Correct," I replied. "You now have a balance-to-unbalance transformer that will work well over the range of 6 MHz to 30 MHz. It will take a kilowatt with ease. In fact, the balun works very well at 3.5 MHz, and also up to 35 MHz. At 3.5 MHz, however, the transformation is not quite unity, as a 50 ohm load "looks like" about 54 ohms at the input terminals of the balun. Still, that's pretty damned good performance."

"It should help the s.w.r. performance of the beam," said Pendergast.

"Negative," I replied. "If the balun is a 1-to-1 transformer, the s.w.r. on the line will not change. However, certain advantages do accrue with the use of a balun, particularly with a beam antenna. First, the balun prevents antenna currents from passing down the outside of the coaxial line. Line radiation can screw up the pattern of a good beam and produce some very puzzling effects. The most apparent effect is the loss of front-to-back ratio. Since coaxial transmission line carries some degree of antenna current when it is attached to a balanced driven element, line radiation will alter the antenna pattern. If the transmission line descends vertically below the antenna, it becomes a fine vertical antenna, radiating

energy in all directions. This is usually unnoticed by the operator, until he finds that line radiation obscures the front-to-back ratio of his beam.

"In addition, antenna line currents travelling on the outer surface of the coaxial line can provide some weird s.w.r. measurements when an s.w.r. meter is inserted in the line. Most inexpensive s.w.r meters react to antenna current in an unpredictable way. The best bet is to use a balun at the antenna and remove this unwanted antenna current on the line. The balun won't change your s.w.r., but probably the s.w.r. reading you get *with* the balun is more correct than a similar reading made *without* the balun."

"How about a compact wide-band balun," asked Pendergast. "I've seen some baluns advertised that cover 3.5 MHz to 30 MHz and are only 2 or 3 inches long."

"Well, judging from the physical size, they are probably ferrite-core baluns," I replied. "As in the case of the air core balun we just discussed, the bandwidth is limited at the high frequency end by shunt capacitance and leakage reactance. The low frequency limit is defined by the shunt inductance. In order to keep the leakage reactance small, the winding should have as few turns as possible. This calls for a high permeability core of small size. Such a core is very heavily loaded. The power capability of this type of balun is limited by core temperature, which might become quite high. As the temperature increases, a runaway temperature is finally reached where operation is impractical because of unbalance in the device. If this keeps up for long, the balun will be destroyed by heat. So, you see, the common ferrite balun provides greater bandwidth at the expense of a power limitation.

"You can wind a simple ferrite balun on a rod of ½-inch diameter ferrite material of good quality. I use Q-1 rod material which has medium permeability. Good ferrite material is not easy to find, and most radio or electronic distributors don't carry it in stock. You can wind a toroid, if you like, but the toroid core costs more than the rod, and it is much harder to wind. Frankly, it doesn't seem to work any better, either. So I suggest you stick with the ferrite rod. You can get information on ferrites by writing to: *Indiana General Corp.,* Ferrite Division, Keasby, N.J. 08832. Ask for information on their ferrite rod #CF-503 and a list of distributors which carry the rod, or who can order it."

"Assume I have the rod," said Pendergast. "What do I do next?"

"The rod is about 7½" long. You'll only need a piece about 2½" long, so you can get three balun cores out of one rod. It is easy to break the rod. Nick it with a sharp file around the circumference at the desired length and break it with a sharp blow with your palm. The brittle rod will snap neatly off, following the scribed line.

"The winding is called a *trifilar* winding because it consists of 3 windings wound in parallel. Each winding is 6 turns, for a total of 18 turns on the core. Number 14 wire is used. Enamel-coated wire can be used, but *Formvar*-coated wire is better. *Formvar* wire can often be gotten from outfits that rewind electric motors. *Nyform* or *Nyclad* wire is even better, as it has the highest dielectric breakdown strength. However, I had to settle for *Formvar.* All you need are three lengths of

[*Continued on page 65*]

Antennas [*from page 45*]

wire about 15" long, each. This gives ample wire for the coil, plus generous end leads.

"The three wires are wound as one. Fasten the far ends in a vise, and you can wind the coils on the core very easily."

"How do you fasten the ends?" asked Pendergast.

"I was afraid you would ask that," I replied. "It's not so easy. The coils tend to stay in position, if you wind them with a little tension. You don't want to use coil dope, or cement on the windings, as that increases the distributed capacity. After you make the cross-connections, you can wrap the end turns with twine and epoxy, or cement the last turn at each end to the ferrite material. That will do the job.

"The inner of the three wires is cross-connected at the ends to the other windings, as shown in fig. 5. This winding is called the *balancing winding*. The point at which the balancing winding is connected to an outer winding is taken for ground at the input end of the balun. That's the point to connect to the shield of the coaxial line."

"Right," said Pendergast. "And I take it that this is a one-to-one balun, also."

"It is," I agreed. "And very handy, too. It will take one kilowatt PEP input to the transmitter on voice up through the 20 meter band. At 21 MHz, the power handling capability is about 500 watts PEP transmitter input and at 28 MHz, about 300 watts p.e.p. input. About the same on c.w., too. You can push it harder than this, but the core starts to run warm. Since I have no means of measuring temperature, I don't know the ultimate power capability of the device."

"Very nice," said Pendergast. "Easy to build and inexpensive. But what about the weather? How do you go about waterproofing the ferrite balun?"

"First of all, you don't want to place any material in proximity to the windings that will alter the characteristics of the balun," I replied. "You shouldn't dip it in epoxy or spray it with *Krylon* or other aerosol sealant.

"A good way to waterproof the ferrite balun is to place it in a plastic bottle and seal the bottle openings. Polystyrene bottles are nice to use for a job like this. Better still, is to place the balun in a section of PVC plastic pipe about 2 inches in diameter and 6 inches long. Cut PVC discs to fit the end of the pipe from sheet PVC material. Place coaxial fittings, or whatever terminals you choose, on the discs and wire up the balun to the terminals. When everything is ready, then cement the discs to the section of tubing. That makes a neat,

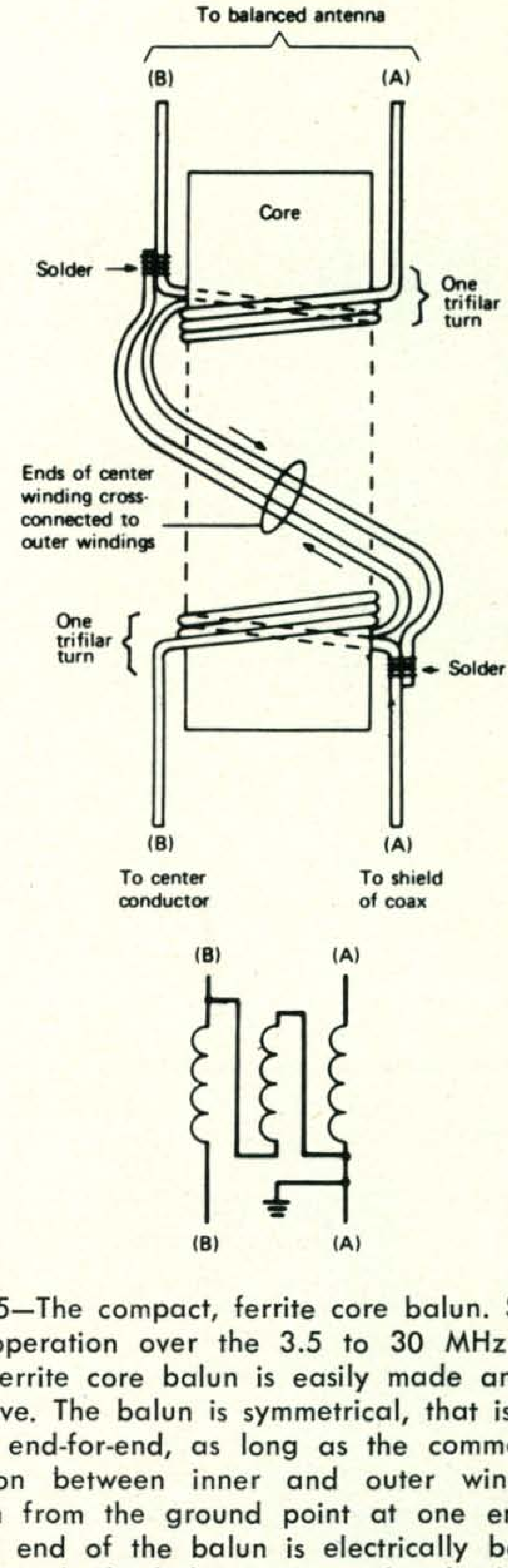


Fig. 5—The compact, ferrite core balun. Suitable for operation over the 3.5 to 30 MHz range, the ferrite core balun is easily made and inexpensive. The balun is symmetrical, that is, reversible end-for-end, as long as the common connection between inner and outer winding is taken from the ground point at one end. The other end of the balun is electrically balanced to ground. The balun is a very handy device to place between a coaxial line and a split, driven element of a beam antenna. It will work well with triband beams, or Quads, provided the s.w.r. on the transmission line is reasonably low (below about 2 to 1). As the s.w.r. on the transmission line increases, the power handling capability of the balun decreases.

rugged and completely waterproof enclosure, provided the terminals, or fittings don't leak."

Pendergast sighed, "Yes, and you can always go out and buy a balun and save the time and trouble."

"Yes," I agreed. "It becomes harder and harder to build your own equipment. Parts are not commonly available and—when you do build up something nice—it has no trade-in

value, as opposed to a commercial piece of equipment. It l ooks as if the hard laws of economics are making appliance operators of us all." ■

CQ Reviews Kenwood TS-900 *[from page 28]*

FIRST IF REJECTION—45 db (70 db min >85 db on 40 and 10). SECOND IF REJECTION—(Not measurable). IMAGE RATIO — >50 db down from output signal (−54 db). STABILITY —100 Hz during any 15 min period after warmup (20 Hz), ±2kHz during first hour after 1 min. warmup (±0.5 kHz). S-METER—(S-9=26 μv 80-15, 10m. S-9=45 μv. 6 db per S-unit and correctly calibrated to +40 db). FRONT END DE-SENSING FROM STRONG ADJACENT SIGNAL — (1μv @ 14.300 is de-sensed 1½ db by 100,000 μv 10 kHz away). SELECTIVITY—SSB 2.2 kHz 6 db (2.4 kHz), 4.4 kHz 60 db (4.4 kHz); c.w. 0.5 kHz 6 db (0.5 kHz), 1.5 kHz 60 db 1.2 kHz).

Transmitter: SSB PEP OUTPUT-150 watts into 50 ohms (160 w. except on 10m. 150 w.); c.w. output—100 watts nominal (with 230 w. input, 150 w. output 80, 40, 20; 135 on 15 and 125 on 10). CARRIER SUPPRESSION—>45 db down from output (−60 db). SB SUPPRESSION—Unwanted sideband −40 db from output (at 1 kHz, USB −44db; LSB —40 db). HARMONIC RADIATION—40 db down from output (50 db or better on all bands). SPURIOUS EMISSIONS—(None detectable within amateur bands when properly neutralized).

Conclusions

As the reader might suspect, we found the Kenwood TS-900 to be an excellent all-around piece of equipment. Only a few small additions would be worthwhile improvements to the operating convenience of the rig. The most significant addition we'd like to see is a provision to use the 2.2 kHz i.f. filter for c.w. reception when band conditions permit. The optional 0.5 kHz filter is excellent under crowded conditions but too sharp for casual operation. Also, we would have liked to see a quieter blower switched on along with filament voltage.

But all in all the TS-900 is the most sophisticated transceiver we've reviewed to date. With the rugged leather carrying handle on its side and rubber feet on the opposite side, it's an easily carried full feature station. Power supplies are available for home station or mobile use, the former being in a matching package with built-in speaker.

The Kenwood TS-900 is imported and distributed by Henry Radio of Los Angeles, California and is priced at $795.00. The PS-900 a.c. power supply is $120.00; the DS-900 mobile supply is $140.00. The VFO-900 is $195.00. The optional CW-900 c.w. filter is $45.00.

—*K2MGA*

antennas

BY WILLIAM I. ORR,* W6SAI

"What's a KLM?" asked Pendergast.

"What's a *what?*" I replied evasively.

"A KLM. It's a new, super, *super* antenna. I heard one on 20 meters a few days ago in a pile-up. *Man!* What a signal. What do you know about it?"

"You must be a mind reader," I replied. "How would you like to have a sneak preview of my March *CQ* Antenna Column? It has a discussion of the KLM antenna prepared by Mike Stall, K6MYC, one of the best antenna designers I know of."

I searched through the desk drawer and brought out a typewritten manuscript. "Here's what Mike has to say about the KLM. Why don't you read it, while I take a quick look-see over 20 meters and see what's going on." I turned toward the operating table as Pendergast settled down in his chair and began to read.

The KLM Antenna

The KLM antenna is an adaptation of the popular Yagi array to obtain better bandwidth performance while retaining the high forward gain and good front-to-back ratio of the Yagi.

In general, the Yagi provides the greatest gain per unit size of any of the popular amateur arrays, but as the gain increases with the number of elements, the more restricted will be the bandwidth of this type of antenna. A high gain Yagi for operation on the 2 meter band, for example, will only provide good performance over a portion of the band. Even at 20 meters, it is not easy to obtain a good match, and good front-to-back ratio, for both the c.w. and phone parts of the band.

The restricted bandwidth of a radiator may be improved by applying the *equiangular principle* to the antenna design. That is, if the shape of the antenna can be specified entirely by angles, antenna performance would be independent of frequency.

A frequency independent antenna, of which the *log periodic array* is an example, is a structure that exhibits the same performance at different frequencies by virtue of the fact that the antenna is self-scaling and has no dimensions that are frequency sensitive. A simple frequency independent antenna described by angles is shown in fig. 1. Practical structures are limited in size and thus limit the frequency independent characteristic. To be truly independent, a spiral antenna of this type would have to start at an infinitely small point and expand to infinity. Practically, the antenna has a feed point at the center and has outer limits. As a result, the antenna has frequency limits defined by the physical, not the electrical, limitations.

A modified, frequency independent antenna is shown in fig. 2. This is a planar structure, with the design repeated *periodically* with respect to the *logarithm* of the frequency. It is known as a *log periodic antenna.* A simpler form of log periodic antenna is shown in fig. 3, wherein the toothed structure is replaced with simple, dipole elements. This is known as a *log periodic dipole* array, and is a popular configuration for television receiving antennas. Radiation is directed toward the apex when used for transmitting, and versions of these antennas are used by amateurs on the v.h.f. bands.

The antenna has frequency limits that are defined as the frequencies at which the outer elements of the array are about one-half wavelength long.

The dipoles are fed at the center from a parallel wire transmission line in such fashion

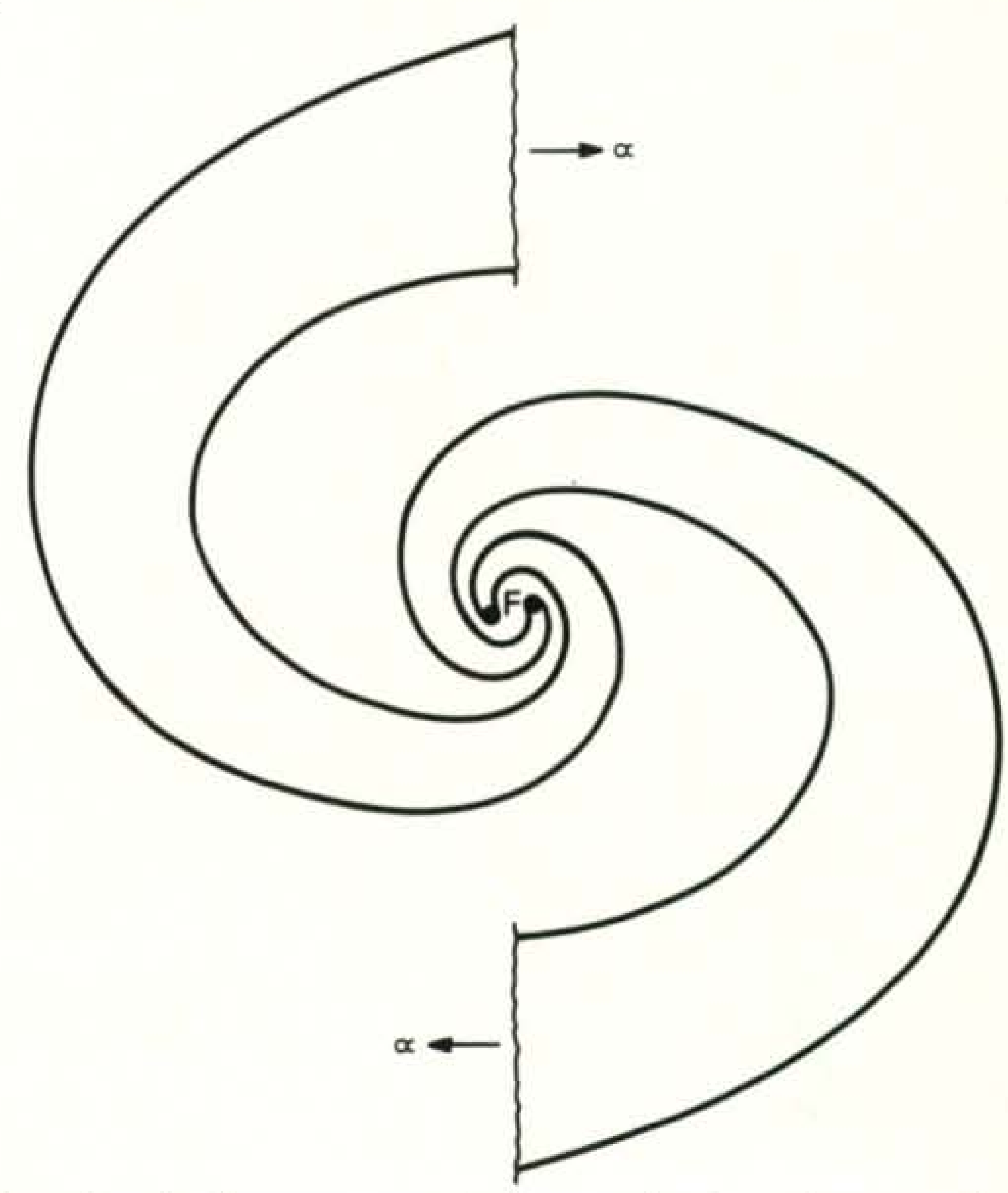


Fig. 1—A frequency independent antenna structure described by angles. The shape of the antenna, when expressed in terms of operating wavelength, is the same for any frequency. The structure is fed at the center point (F) and the arm lengths are infinite. (Illustration courtesy of Editors & Engineers, Ltd.)

*48 Campbell Lane, Menlo Park, CA 94025.

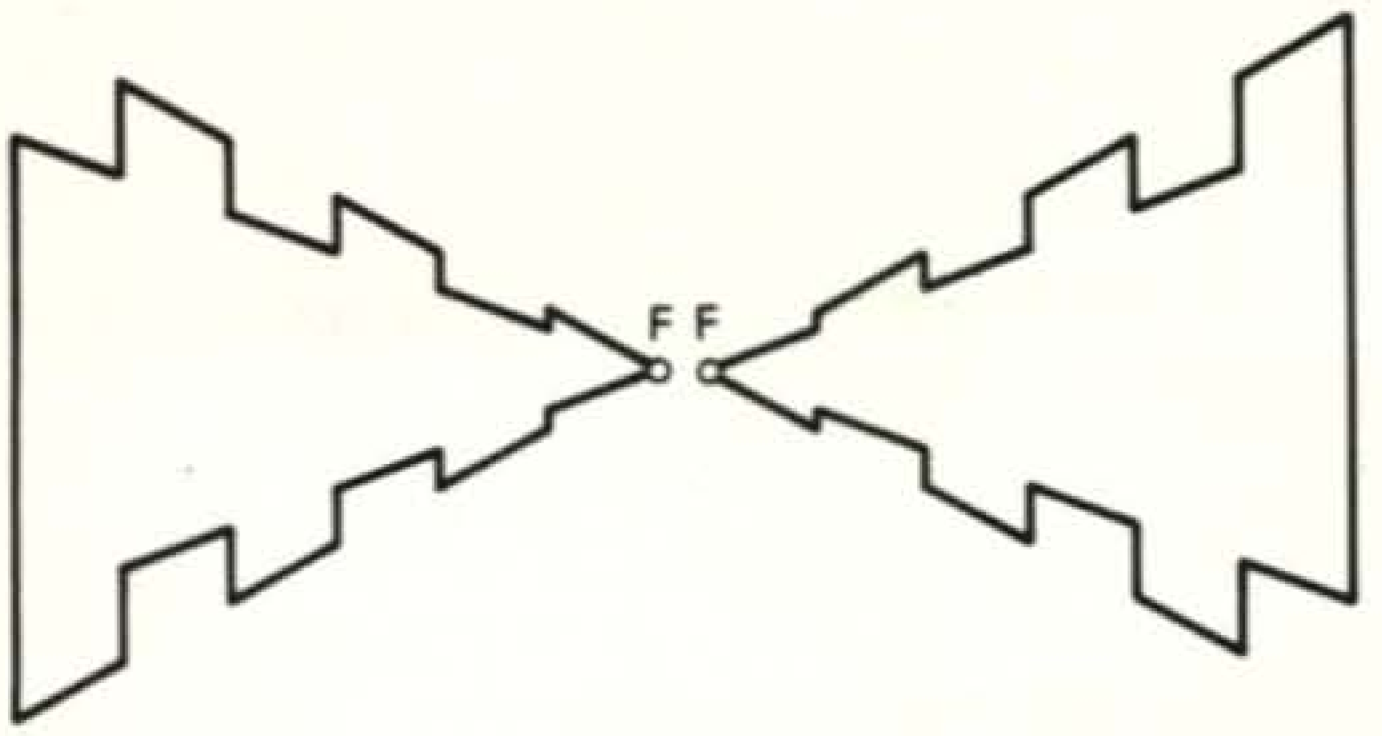


Fig. 2—A planar, pediodic antenna. The toothed structures can be cut from a sheet of aluminum or other conducting material. Feedpoint is F-F. The structures may be folded back upon themselves to form a three dimensional, directional array.

that successive dipoles come out from the line in opposite directions, equivalent to a 180 degree phase shift between elements. A broadband structure is thus formed, with most of the radiation coming from those elements in the vicinity of a half-wavelength long. Gain and bandwidth thus bear a definite relationship to the included angle of the structure, and its length.

The log periodic principle may be applied to the Yagi antenna to expand the bandwidth of this popular antenna. Enough log periodic, driven elements are added to the Yagi beam to provide the desired bandwidth and are fed in the same manner that the log periodic assembly is fed. The number of log periodic elements used depends upon the bandwidth desired.

As a specific example, a 20 meter log periodic Yagi antenna will be discussed.

* * * * *

Pendergast put down the paper and said, "How in the world do you design a 20 meter beam antenna? It's too big to do much experimental work on, and you would need a huge antenna range."

I took off the earphones and replied, "Right. K6MYC developed his 20 meter design by scaling all dimensions down by a factor of ten and making all tests and measurements at 140 MHz. He set his model antenna up one wavelength above ground, or 84 inches. The 20 meter elements were duplicated by using ⅛-inch diameter elements."

"What about the ground plane?" asked Pendergast.

"Mike ended up using natural ground," I replied. At 140 MHz, it compares favorably with 14 MHz. Of course, the comparison is not so true at microwave frequencies.

"I understand one of the local microwave outfits has made a good approximation of actual earth conditions by using a copper ground plane covered with peanut butter for work at 2.5 gHz."

"Peanut butter?," cried Pendergast.

"Yes," I replied. "Peanut butter makes a good approximation of the ground losses for antenna measurements in the microwave region."

Pendergast muttered some uncomplimentary remark under his breath and continued to read the manuscript.

* * * * *

It was soon found out that the tapered elements used at 20 meters could cause significant errors when the elements were scaled up from 140 MHz. The initial design, which used untapered elements, scaled up to a much higher frequency than expected. This was due to element taper on the 20 meter antenna, whereas the 140 MHz model used ⅛-inch diameter elements, butt to tip. This corresponded to 1¼-inch elements at 14 MHz. Using 14 MHz elements that tapered from 1¼-inch at the butt down to ½-inch diameter at the tip required a lengthening of approximately 5 percent to lower the antenna to the desired operating range of 13.9 MHz to 14.4 MHz.

This frequency range for the 20 meter KLM log periodic Yagi was chosen because many amateurs also operate on the MARS frequencies close to 14 MHz. Making a standard Yagi antenna perform optimumly on the MARS frequencies as well as the high frequency end of the 14 MHz band is compromising, if not impossible.

A twin log-driven element system has sufficient bandwidth to cover 500 kHz at 14 MHz and parasitic elements, if properly designed and spaced, respond well when driven over that range. The final antenna design for 20 meter operation provided good gain as low as 13.6 MHz, although the front-to-back ratio and s.w.r. were poor below 13.9 MHz (fig. 4).

* * * * *

"Figure 4! Figure 4! Where is it?" yelled Pendergast.

"You dropped it on the floor," I replied. "Here it is."

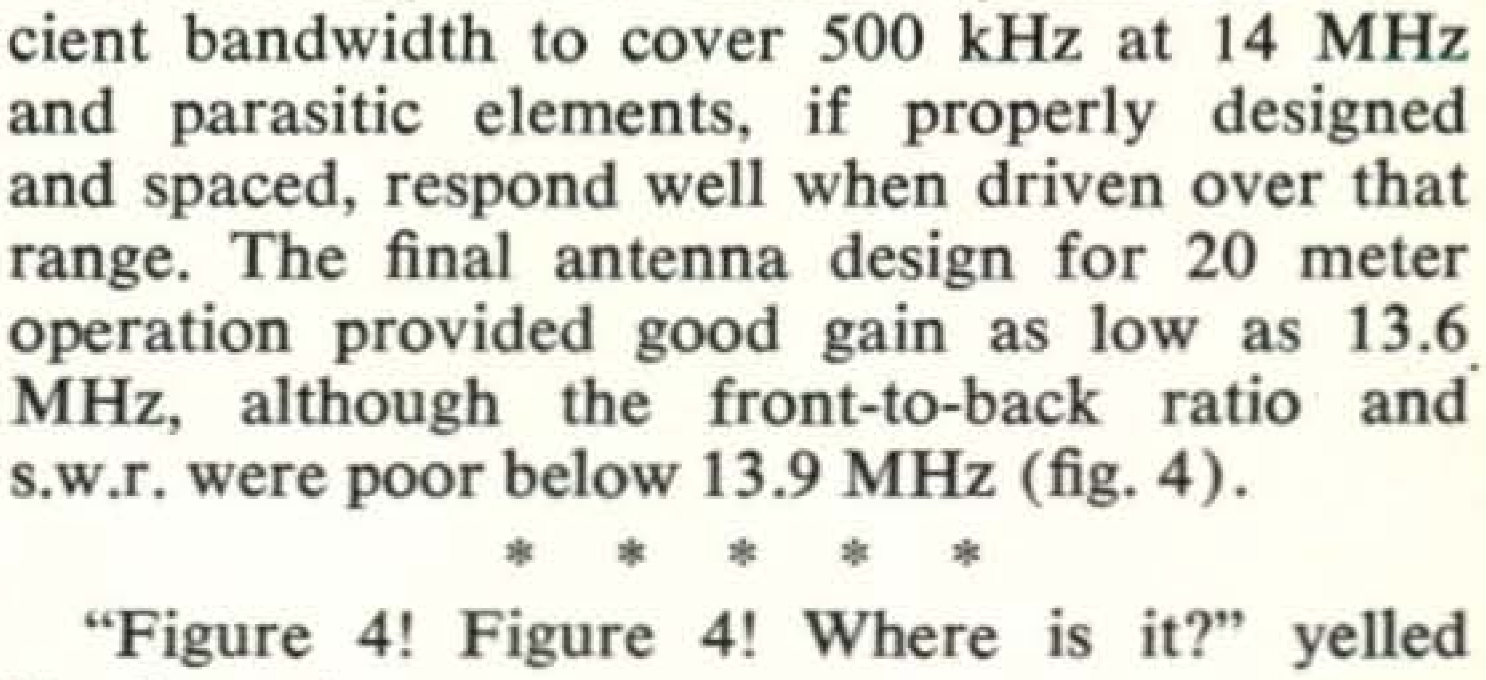


Fig. 3—The log periodic dipole antenna. Successive dipole elements are fed out of phase by a common transmission line to produce a beam pattern at the apex of the array. The lowest usable frequency is determined when the longest element approaches a half-wavelength. The highest usable frequency is determined by the length of the shortest element. The antenna is fed at F-F with a balanced line, or coaxial line and balun.

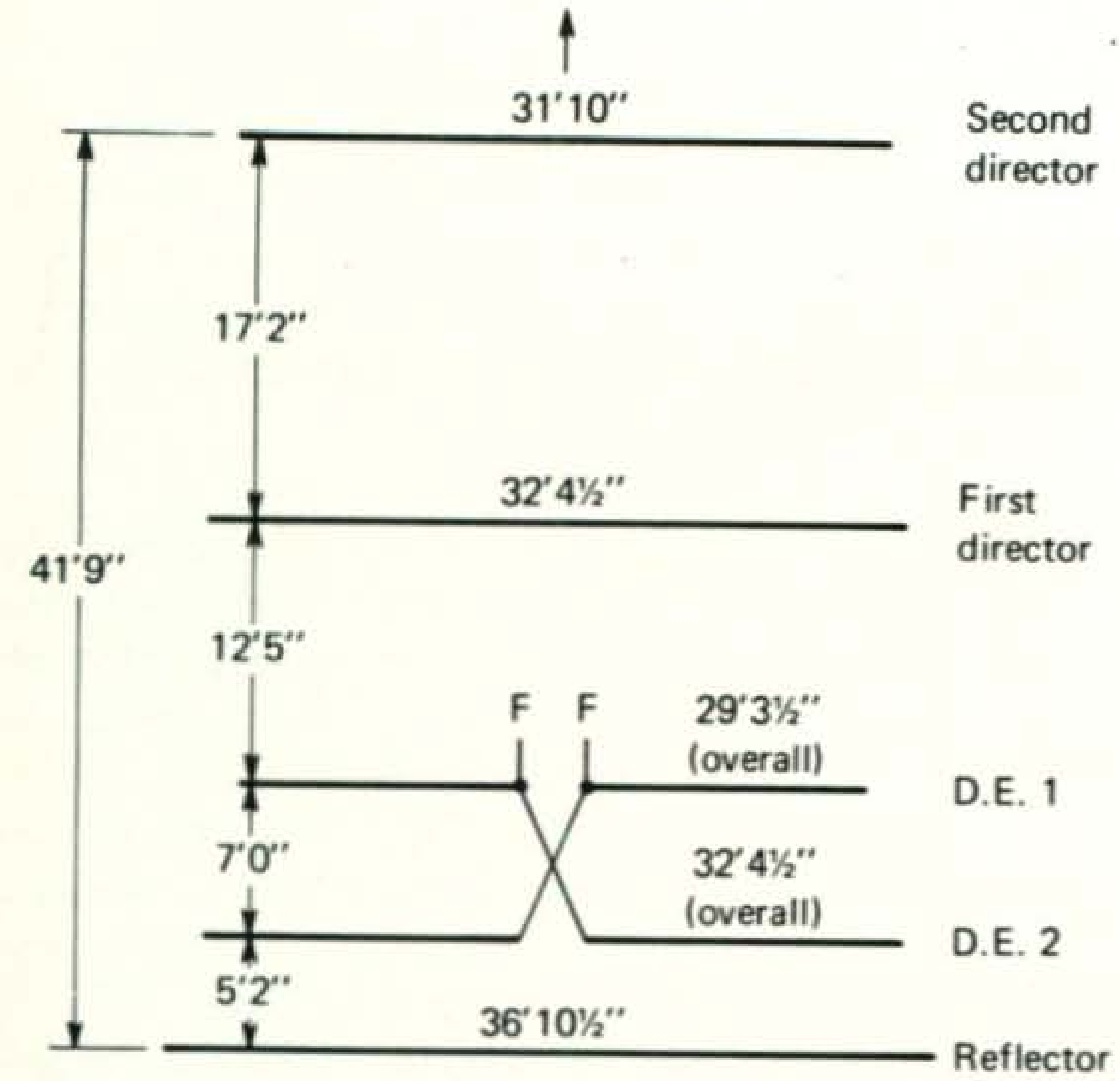


Fig. 4—The KLM 20 meter "big gun." Covering the range of 13.9 MHz to 14.4 MHz, the KLM design provides 9 db forward gain over a dipole across the operating span. Front-to-back ratio is 30 db at the design frequency of 14.25 MHz. Antenna is built on a 42 foot boom and is fed at points F-F with a 50 ohm line and a coaxial, half-wave balun which provides a 200 ohm termination to match the antenna. Antenna dimensions provided by K6MYC.

Pendergast bent over the drawing. "This is the antenna design that shot me out of the saddle on 20 meters," he announced.

"Well, it is a 5 element structure, using two log-driven elements. That makes it about equivalent in power gain to a 4 element Yagi. Only difference is, you can actually get this gain all across the operating range. And it is difficult to do that with a simple Yagi. Mike claims 9 db forward gain over the operating range, as compared against a dipole, and I see no reason to doubt him."

Pendergast peered at the drawing and I continued. "Notice that reflector spacing is narrow to conserve boom length, which is an important factor on a large antenna. The front-to-back ratio is affected very little with reflector spacing in the range of .08 wavelength to .25 wavelength. Forward gain rises 0.3 db with the reflectors spaced out at .25 wavelength, but this is hardly worth the extra boom length.

"The spacing of the driven element pair is adjusted to provide a 200 ohm impedance for the antenna feed point. Spacing variations here have little effect on antenna performance. Notice that the lengths of the two driven elements are diffierent. The lengths are affected by the proximity of the reflector and the first parasitic element and these lengths, when properly adjusted, provide the proper bandwidth in this configuration.

"First director spacing is adjusted to achieve a match at the feed point and also has a significant effect on the front-to-back ratio. The length of the element also affects these parameters, but has the most effect on the antenna gain."

Pendergast picked up the manuscript and began reading again.

* * * * *

The forward director, which is the shortest, is used to control the high frequency response of the antenna. Adjusting the length controls this parameter. The spacing of the outer director also has a significant effect on the front-to-back ratio of the array.

The individual spacings of the two directors are adjusted for maximum forward gain and a high front-to-back ratio. Adjustments are then made to the driven element lengths to bring the impedance match to provide a s.w.r. of 1.2, or better, over the 500 kHz range covering 13.9 MHz to 14.4 MHz.

In this particular design, the directors exert a high degree of control over the front-to-back ratio, not only how much, but also where the highest ratio occurs in the passband. Since 14.2 to 14.25 MHz is probably the most desirable place to have the best front-to-back ratio, the director spacing and lengths are adjusted to provide at least 30 db ratio, or better, in that frequency region. The front-to-back ratio decreases to 20 db, or better, at 13.9 MHz and 14.4 MHz. Maximum gain varies only 0.2 db over the complete passband of the antenna.

* * * * *

"Wow," said Pendergast. "My 4 element Yagi has only about 15 db front-to-back ratio in the phone band, and even worse at 14.0 MHz!"

"Yagi antennas are not noted for good front-to-back ratio, except when expressly designed for it. Then you always run the risk of losing forward gain," I replied.

"Let's digress for a moment and talk about directors," I said.

"Directors will do their job over quite a wide frequency range. The big problem with most common Yagi designs, using a single driven

[*Continued on page 66*]

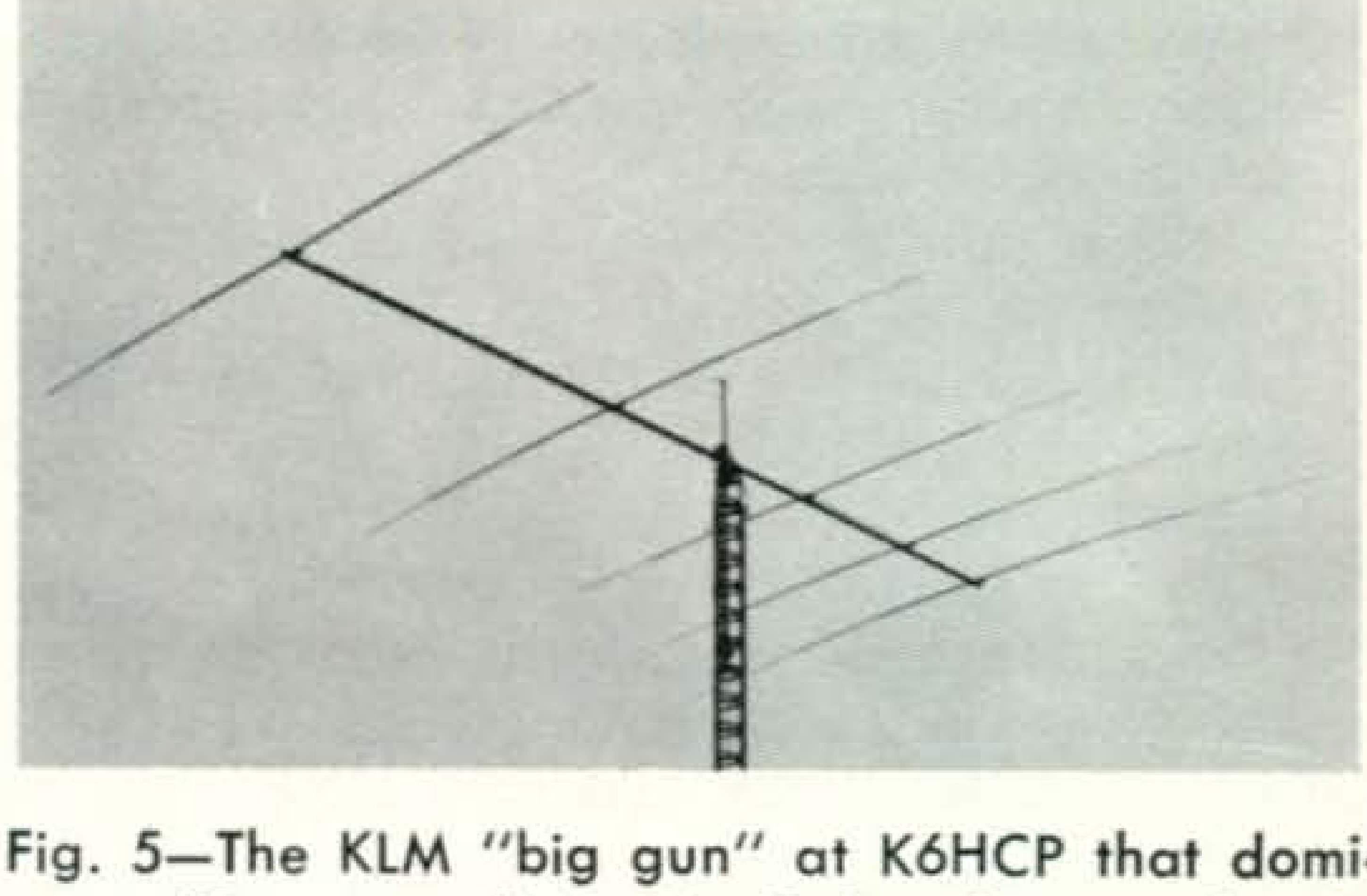


Fig. 5—The KLM "big gun" at K6HCP that dominates 20 meters. Boom is 42 feet long and gain over a dipole is 9 decibels.

Antennas [*from page 22*]

element (as opposed to two elements in the KLM antenna), is that with the addition of the various parasitic elements, the Q or circuit selectivity, of the driven element rises sharply and the usable bandwidth shrinks. That gives you a severely restricted s.w.r. curve. If you can properly excite the directors, they will perform well over several hundred kilohertz of the 20 meter band—about 4 percent of the design frequency, in fact.

"The KLM dual driven element excites the directors over a wider frequency range than does the simple dipole, thus providing wide, flat, optimum gain and excellent s.w.r. characteristic.

"The s.w.r. response of the KLM design can be adjusted somewhat by fiddling with the director spacing and length, but since the directors are optimized for gain and front-to-back ratio, anything but very small changes will result in performance degradation.

"Thus, the s.w.r. curve can best be adjusted by paying attention to driven element lengths and spacing. It turns out that the spacing between the driven elements has little effect on s.w.r., but driven element length can be adjusted easily to touch up the s.w.r. figure to less than 1.2 across the operating range. Gross changes in length, of course, will screw up the front-to-back ratio.

"As in any beam design, the dimensions are interlocking to an extent, and you have to know what you're doing, or you'll end up chasing yourself around in a circle."

"I'd sure like to see a KLM antenna," said Pendergast. "How long is the boom?"

"About 42 feet," I replied. "It's a *big gun*, but it takes a big antenna to deliver a big signal. Here's a picture (fig. 5) of the KLM antenna at Mike's station, K6MYC."

"That's the guy who shot me down in the pile up," said Pendergast.

"Well, you now have all the design information to build your own antenna," I replied. "Or, you can get the manufactured model made by KLM Electronics. That's how the antenna got its name."

"The grandfather and first user of the log periodic Yagi antenna was an amateur by the name of Oliver Swan, who perfected this unique concept for long distance television work in the central valley of California. The antenna performed so well that amateurs started using it for DX work on 6 and 2 meters. It consistently outperformed Yagi antennas of equivalent size. K6MYC did a lot of work with the v.h.f. designs, before he perfected the 20 meter version. K6HCP and K6KBE were also in on the project. And these three calls are *very* well known at the v.h.f. antenna measuring contests held each year in California. They are the fellows to beat, and not many guys can whip them, as far as antenna design goes."

"Well," said Pendergast, I'll be looking forward to the March issue of *CQ* to read all about the KLM antenna. Of course, since I have already read the material, by the time the magazine comes out, I'll be an expert!" ■

Cop's Column [*from page 30*]

Skokie, Illinois 60076) sells small arrays which appear well suited to charging batteries for hand-held transceivers and low power h.f. rigs such as the Argonaut. For example, their SPM 150-12 solar power module is 7″ × 8″ × 0.44″, costs $100.00, and will deliver a current of 120 ma at 12 volts in direct sunlight.

Because of the high cost per watt of natural power with the sources available today, it is very important that all gear powered by them draw the minimum current possible. Solid-state design is a must, but in itself is not a guarantee of minimum power drain. Pilot lights need to be shut off, and switching should be designed so that only the stages in actual use at any particular time are receiving power.

A Farewell Of Sorts

With very mixed feelings and a large measure of regret I'm passing the word along that this will be the last "Cop's Column," at least for awhile. Cop is on the move again, this time to Halifax, Nova Scotia. While you will still be seeing my byline in *CQ* and elsewhere, I'm just not going to have the time to turn out a worthwhile technical column each and every month. Many thanks for the support you've given me during these past 32 months. We'll still be getting together via the pages of *CQ*, and perhaps now a little more often on the air too. It is one of the ironies of writing regularly for a ham magazine that you don't have much time for hamming! I'm hoping now to have at least a little more time to spend communicating with old friends and meeting new ones. 'Til the next time we meet, Vy 73, Cop, WØORX/VE1

antennas

BY WILLIAM I. ORR,* W6SAI

"What are you doing," said Pendergast as he slouched down on his spine in my favorite easy chair. "Working on your income tax return?"

"Thanks a lot," I replied. "I don't do *that* until the last possible moment. And this isn't the last possible moment."

"Well," Pendergast replied, "Let's talk about something *nice*. Have you gotten any interesting letters about your *CQ* column?"

"Plenty," I replied. "Especially the column on vertical antennas. I'm still getting feedback on that one. Also 'invisible' antennas are a hot subject. And 80 meter antennas are coming into interest, as the sunspot cycle drops. Lots of interest in 80 meter DX antennas."

"Suppose you let me hear some of the letters," suggested Pendergast.

"Why not?," I replied. "Here's a short note from Joe, WA7GSM, who has an interesting 80 meter antenna. It is a modified Quad loop (fig. 1) whch is slung from a single 45 foot pole. Each antenna corner is about 25 feet off the ground and the feed point is 8 feet off the ground . . . sort of a squashed diamond arrangement. Joe uses a commercial 4-to-one balun at the feedpoint and a 50 ohm coaxial line. He says the diamond seems to present a feed point impedance of about 250 ohms. The s.w.r. runs about 1.5 at 4 MHz, dropping to unity at 3.8 MHz."

"Well, according to that, Joe should be able to use the diamond loop all the way down to 3.5 MHz," said Pendergast.

"It would seem that way," I replied, "Although he didn't give any s.w.r. readings below 3.8 MHz."

"Loop antennas are very forgiving," said Pendergast. "I like to use them in preference to single wires, which sometimes can be very nasty."

"Here's another interesting letter from Roger, K8ZKF, telling about his experiences with various antennas. He came to the conclusion that a 20 meter ground plane, ground mounted with 12 radials, was comparable to a dipole at about 30 feet. Out to about 1200 miles, the dipole seemed best in its broadside direction, but past 1200 miles, the ground plane seemed a bit better. He felt in all cases, however, the dipole was better for receiving than the vertical."

"Probably because the vertical antenna is more susceptible to man-made noise than the horizontal," interrupted Pendergast.

"Roger's conclusion is that the biggest mistake hams make with a vertical antenna is to use it as a limted space antenna. For best results, the vertical needs plenty of room around it, and plenty of radials if it is close to the ground."

"I agree," said Pendergast." Look at this letter you got from Bob, HL9UB in Korea. He's within shouting distance of HL9TC, Dick, and they have been running comparisons on phone patches to the United States. Bob started out with a tri-band vertical antenna with the base atop a 30 foot pole. It had four radials for 40 meters and six radials for 20 meters, all sloping down as guy wires. Both Bob and Dick ran the same power. Well, HL9UB's vertical antenna ran about one S-unit worse than the three element Yagi beam at HL9TC, which was 40 feet high. Also, the vertical antenna was noisier on receive than the beam. Eventually, HL9UB raised his ground plane so the base was about 65 feet in the air and found that he and HL9TC were running about equal, as far as signal strength reports went. He says, 'I admit that there are antennas which are better than a vertical, but for limited space, easiness on the eyes (from a landlord's point of view), and overall performance a *high* vertical antenna with *lots of radials* is tough to beat!' "

"Well, HL9UB should QSO Jack, K2JFJ, some time," said Pendergast. "Jack likes a five band ground plane and has worked a staggering

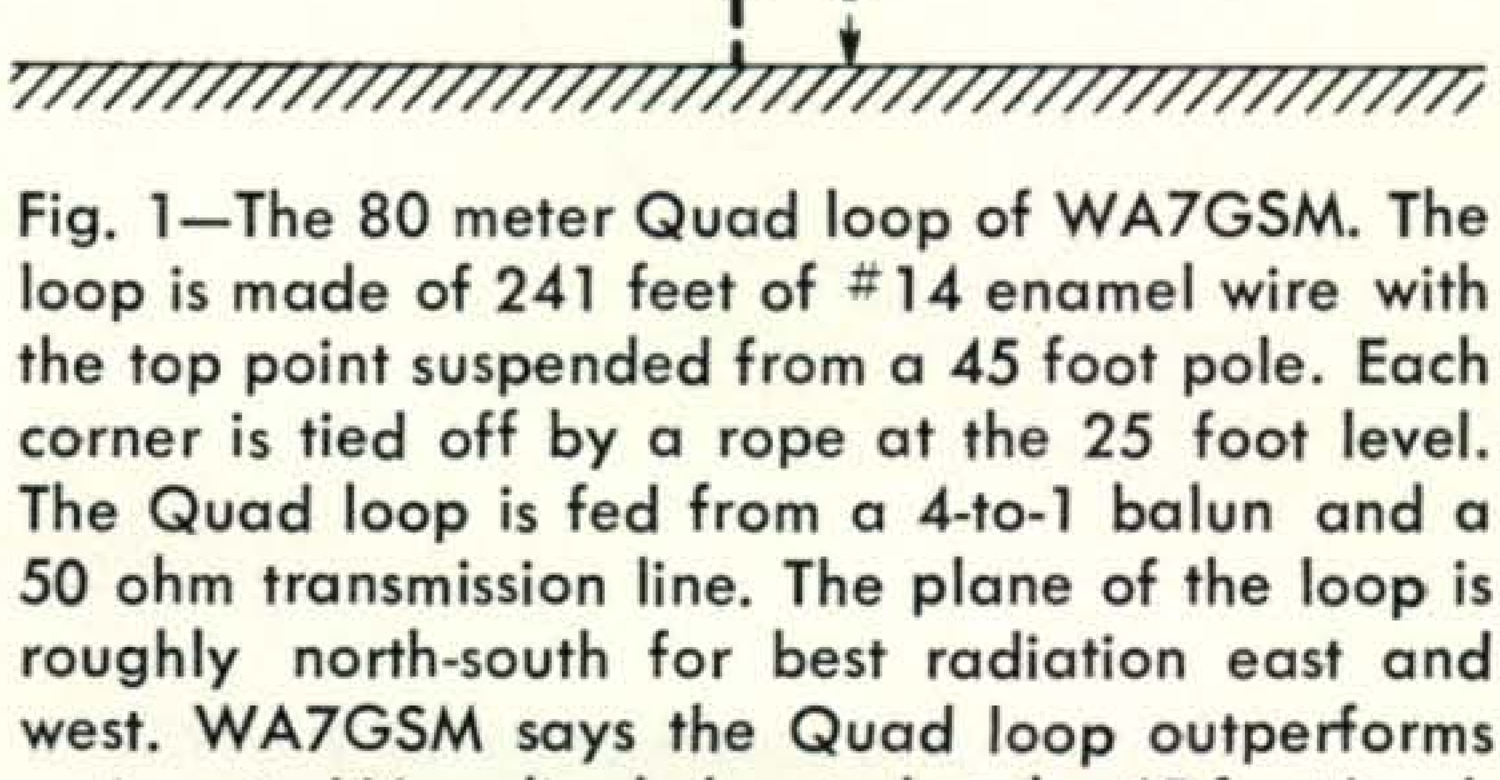


Fig. 1—The 80 meter Quad loop of WA7GSM. The loop is made of 241 feet of #14 enamel wire with the top point suspended from a 45 foot pole. Each corner is tied off by a rope at the 25 foot level. The Quad loop is fed from a 4-to-1 balun and a 50 ohm transmission line. The plane of the loop is roughly north-south for best radiation east and west. WA7GSM says the Quad loop outperforms an inverted V or dipole located at the 45 foot level. He's planning to place a 40 meter loop inside the 80 meter one, and feed it with the same balun and transmission line.

*48 Campbell Lane, Menlo Park, CA 94025.

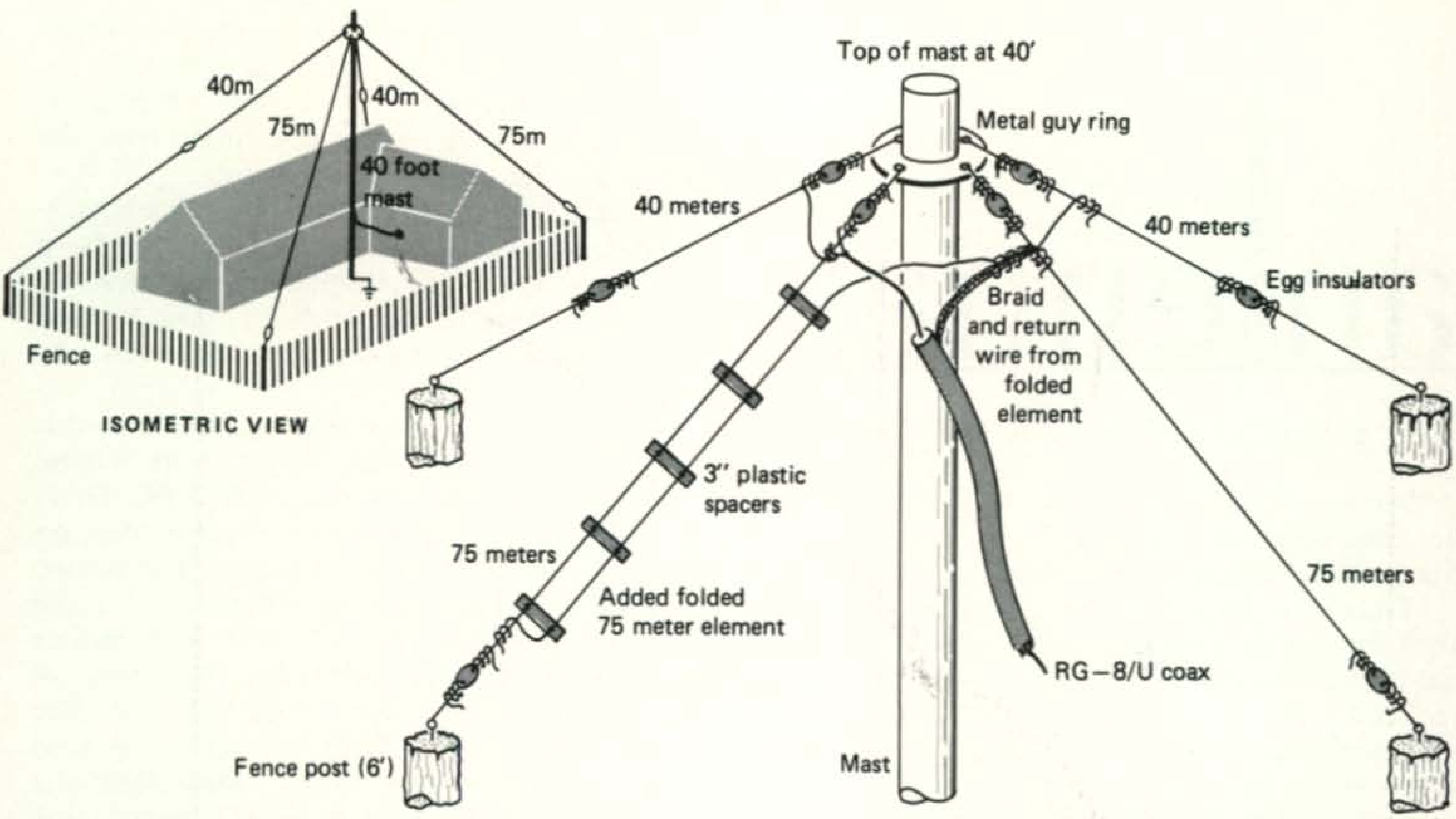


Fig. 2—The W5TNX double inverted-V for 40 and 80 meters. To raise the feedpoint impedance of the 80 meter antenna, the fed-portion is made folded (as shown at left). The center conductor of the coax line is attached to one 40 meter wire and to one of the folded wires of the 80 meter section. The braid of the coax is attached to the other 40 meter wire, to the other 80 meter wire and also to the return wire of the folded 80 meter section.

amount of DX with 150 watts. Anyone who can pull UK7LAJ out of a pile-up on 20 meters with that amount of power must have something going for him. Look at the copy of his log book." Pendergast tossed a thick pile of papers to me that read as if K2JFJ was running a one man DX contest. "Listen to what Jack has to say." And Pendergast read, "My 5 band vertical was intially installed as a ground mounted vertical with 13 radials, buried just beneath the grass. About 17 feet away was a

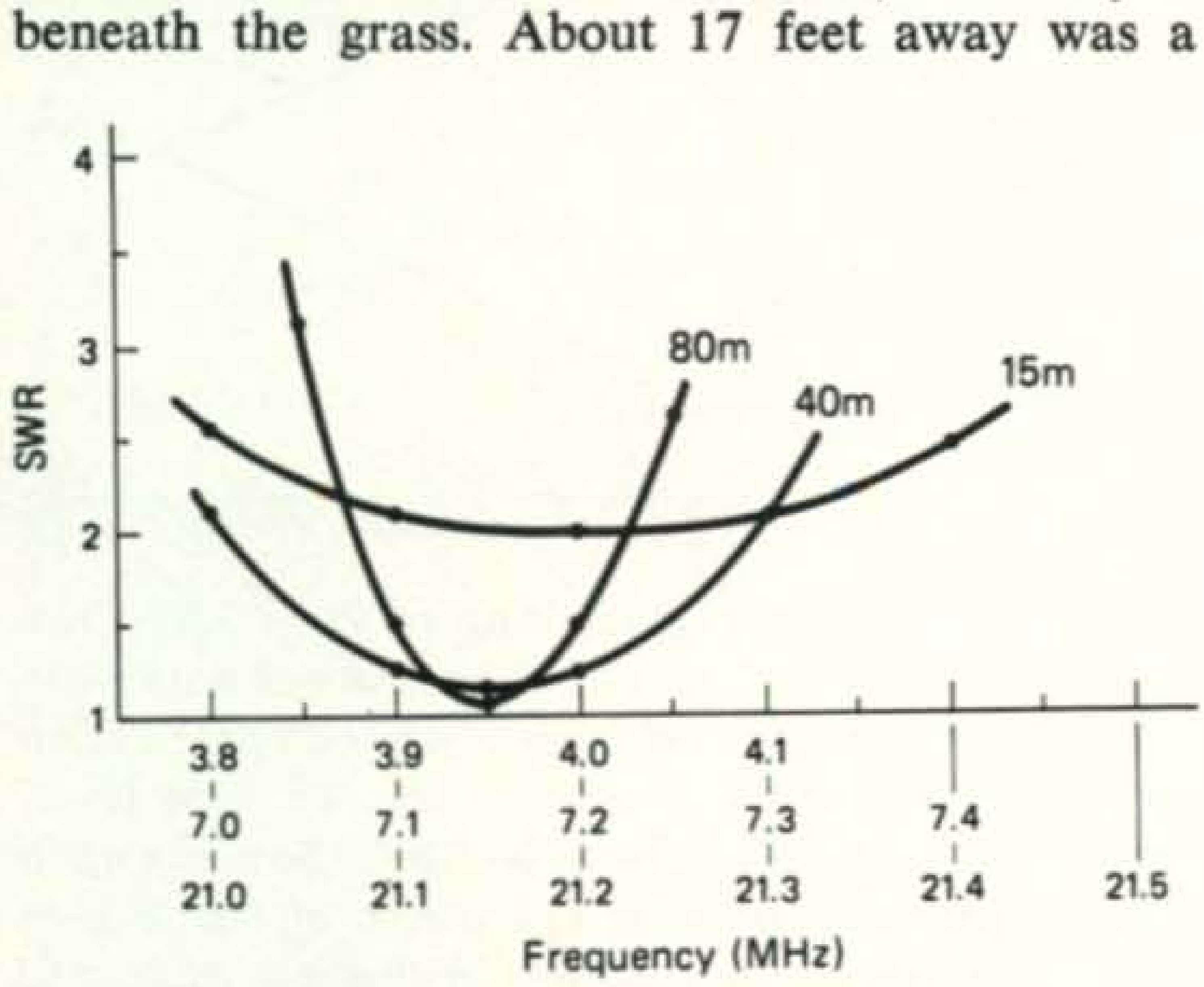


Fig. 3—Representative s.w.r. curves for the W5TNX triband, inverted-V antenna system. Overall length of the 80 meter portion is 120 feet (60 feet per leg). Overall length of the 40 meter portion is 65 feet (32 feet, six inches per leg).

four foot cinder block retaining wall with a 4 foot high chain link fence atop it. Since antenna performance didn't seem too good, I raised the vertical on top of a 20 foot steel pipe and increased the number of radials to twenty. There were 5 radials for 10 meters, 6 for 15 meters, 4 for 20 meters, 4 for 40 meters and one for 80 meters. The radials, instead of being buried, now acted as guy wires for the antenna, sloping down from the 20 foot level. In my opinion, the performance DX-wise improved greatly, as well as the ground wave performance for local rag chews.

"Last year I installed a three element triband beam on a 30 foot tower. Needless to say, the beam outperforms the vertical on comparative tests to Europe. However, when band conditions are top-notch, the reported difference between beam and vertical is sometimes very slight."

"Well, there you are," I said. "It seems that a vertical antenna won't beat a good beam, but if the vertical is high in the air, and has a sufficient number of radials, it will give a good performance and will work plenty of DX. Things tend to get tricky when the vertical is mounted close to the ground, as ground losses and the proximity effects of nearby objects tend to mask out antenna performance." I turned to Pendergast. "Does that sound like the definitive word, as far as vertical antennas go?," I inquired.

"The case is closed," cried Pendergast, "That is, until the next bunch of mail comes in. But I believe that your statement that a vertical antenna is one that radiates equally poorly in all directions is no longer valid."

I ignored the thrust and returned to the pile of mail. "Here's an antenna I like," I said. "It is designed by Jim, W5TNX, who uses it on 75, 40 and 15 meters, in addition to MARS work just outside the top end of the 75 meter phone band (fig. 2). Basically, the antenna consists of two inverted-V dipoles, cut for 75 and 40 meters and supported at the center by a telescoping 40 foot TV mast. The wire elements are cut for the 75 and 40 meter bands and are used as supporting guy lines for the mast. Strain insulators insulate the wires from the mast guy ring and the 50 ohm coaxial line feeds one leg of each dipole while the braid attaches to the other legs. The cable is taped to the mast. The 40 meter dipole operates as 3 half-waves on 15 meters."

"Well, what's so tricky about that?," demanded Pendergast.

"This," I replied. "The antenna exhibited a high value of s.w.r. on 75 meters, probably due to low feed point impedance, as compared to the 50 ohm feedline. Jim raised the feedpoint impedance of the 75 meter system by making *half of a folded dipole,* as shown in the drawing. The resulting s.w.r. curves for the three bands are shown in fig. 3. The exact value of center impedance for either antenna can be varied slightly by raising or lowering the tips of the antennas."

"A good idea," said Pendergast. "The 75 meter antenna resembles a folded unipole, with a single radial wire."

"An apt comparison," I admitted.

"Here's a fun letter from Dave, W3DBA," said Pendergast, rummaging around in the stack of mail. "He's using a drainpipe for an antenna."

"A drainpipe," I exclaimed. "Do you mean a *downspout?*".

"Right," replied my friend. "Dave lives in an apartment where antennas are *verboten.* He's on the ground floor, and the drainpipe, or downspout, is 3 stories tall—about 28 to 30 feet. He tunes it with a homebrew transmatch antenna tuner for operation on 40 through 10 meters. He has a set of 3 haywire radials for each band running close to the apartment wall, near the ground. So far he's worked WAS on 40 meters, and 45 countries including JA and ZL on 20 meters. The shack is in a corner room, near a window, and he runs the radials along two outside walls of the building. Dave says he's pretty well pleased with the results, but sometimes he calls and calls with no results. He says when WWV sends N (normal propagation conditions) he does pretty good, but when WWV sends U (unsettled), he doesn't

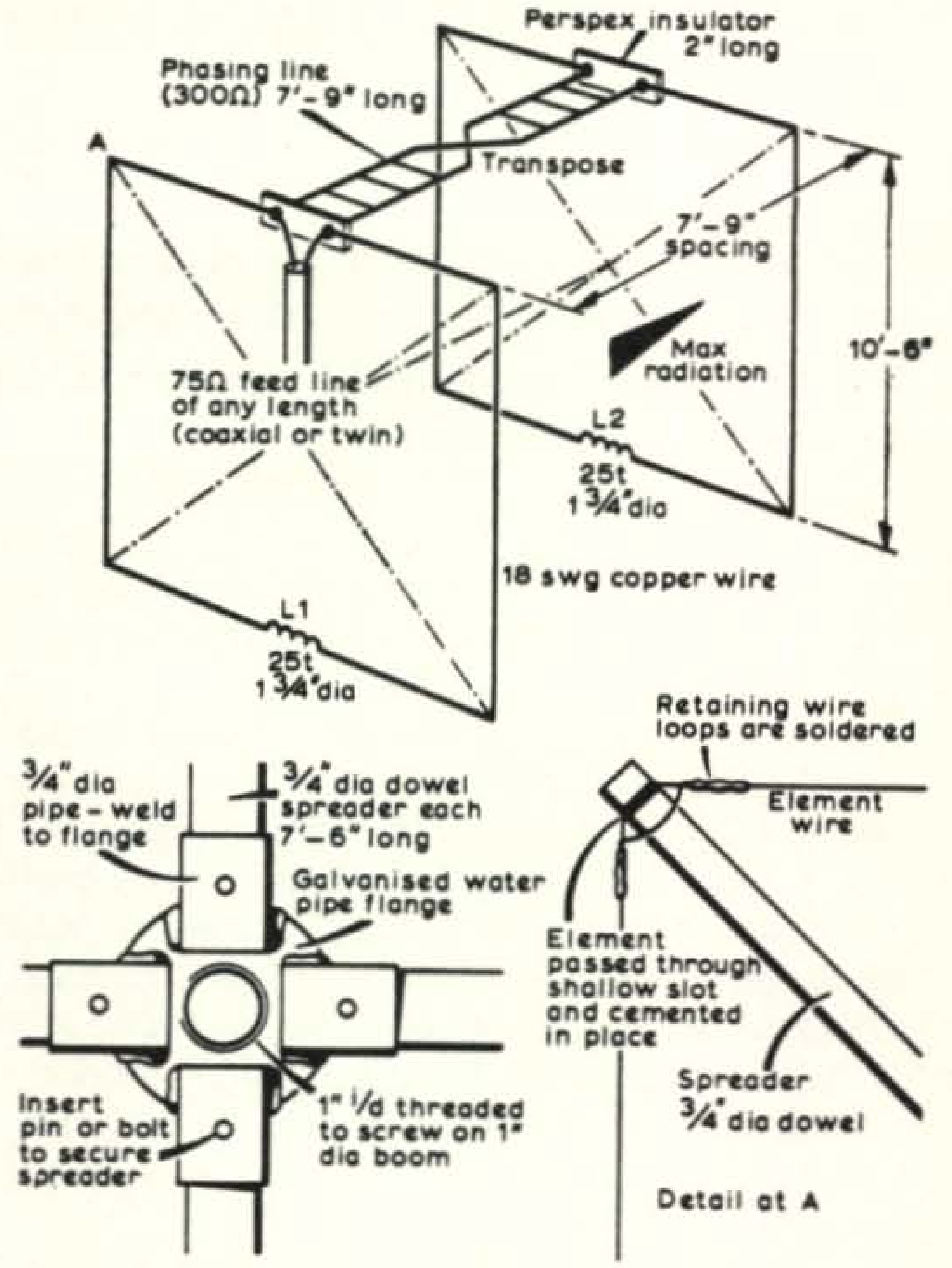


Fig. 4—The G3PHO mini-Quad for 20 meters. Both square loops are driven through a 300 ohm open-wire line (transposed). The rear loop is fed with a transmission line at the top center of the element. Loading coils are placed at the center of the bottom wires of the loops. (Drawing courtesy of *RSGB* and *Radio Communication*).

get out very well at all."

"Maybe WWV has put the hex on him," I replied.

"I can sympathize with Dave," said Pendergast. "When WWV transmits U5, I can't punch my way out of a paper bag." After a pause, Pendergast picked up a small magazine with a bilious purple cover and said, "Did you see the neat mini-Quad antenna in the January issue of *Radio Communication,* the RSGB publication?"

"No," I replied. "The magazine just arrived and I haven't had a chance to look through it."

"Well," said Pendergast, "You had better read your mail quickly. I see a great article by Pat Hawker, G3VA, called *Technical Topics.* He discusses a mini-Quad antenna which was designed by G3PHO, who used it when he was operating as ZL2BDA (fig. 4).

Pendergast continued, "To quote *Radio Communication . . .*" Among the attractions are that it can quite easily be made by one person, is much less conspicuous than a full-size Quad, has a performance at long distances which is claimed to be distinctly better than verticals and dipoles and, indeed, as good as the 14 MHz

[*Continued on page 70*]

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performance of most of the popular triband beams. On the other hand, it is admitted that the front-to-back ratio will be less than for a full-sized Quad (typically 18 to 20 db at low angles, less at higher angles). It should also be noted that as for all compromise and loaded aerials it is necessary to tune and adjust the aerial carefully for optimum performance.

'The following constructional hints are taken from G3PHO's notes:

1—Spider. Cross arms and boom assembly should be as strong as possible and able to withstand high winds. But do not use metal arms, since metal in the field of the loops can cause undesirable effects.

2—Loading coils can be wound up PVC (polyvinyl chloride) tubing, preferably threaded on a lathe for 12 turns per inch. After final adjustments, spray them with clear *Krylon* to keep out moisture.

3—Tune with s.w.r. bridge and grid-dip oscillator. Connect 75 ohm feedline to beam and erect aerial as high as possible consistent with easy access to the coils. Adjust the coils until g.d.o. indicates resonance at 14 MHz for forward element and 14.25 for rear element without adding or removing turns, by using 3-inch lengths of ferrite rod dipped in epoxy cement and sliding the rods in until the correct resonances are achieved, then leave well enough alone until the glue sticks firmly."

"That looks like a nice little mini-Quad," I commented. "My only suggestion, if U.S.A. hams build it, is to switch from 75 ohm feedline to 50 ohm line. It's not easy to get an s.w.r. meter for 75 ohm line, and RG-8A/U or RG-58/U are sometimes easier to buy than

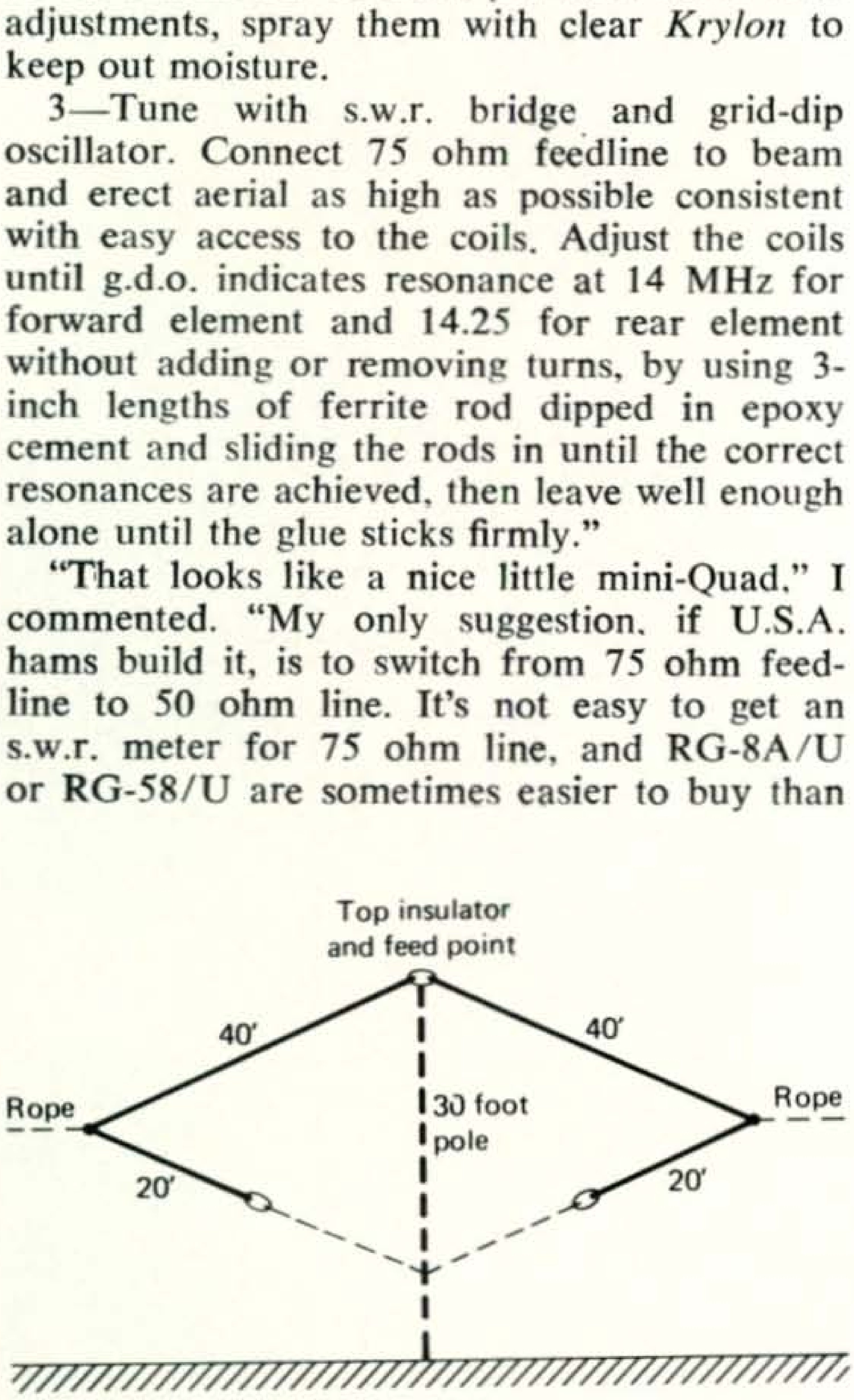


Fig. 5—The inexpensive 80 meter dipole antenna of Clyde, W5OCO. Dipole is supported at the center and takes the shape of a diamond. Antenna is fed at the apex with RG-8/U coax line. Each leg is 60 feet long, with the outer 20 feet bent back and tied to the mast about 6 feet above the ground. A second dipole could be erected at right angles to the first to give omnidirectional coverage using two feedlines and a switch at the operating position.

the 75 ohm line (RG-11/U or RG-59/U). In either case, operation of the antenna is not dependent upon line impedance. it certainly looks like a good design for a small size beam antenna."

"Yes," agreed Pendergast. "A lot of fellows who hesitate to erect a full size Quad antenna may be attracted to this compact design. Hurrah for the RSGB and G3PHO."

"I get a lot of good antenna ideas from *Radio Communication*. I said. "If you can read English, it's a great magazine."

"What do you mean, *if* I can read English," retorted Pendergast.

"We speak American, that's what," I said. "In any event, you can look at the pictures."

Pendergast yawned elaborately. "Anything else before I leave?," he asked.

"One final letter from Clyde, W5OCO. He describes his compact 75 meter antenna, slung from a single pole and tied off to some nearby bushes (fig. 5). Very small and compact. He also remarks about a buddy of his who strung a long, long wire along a picket fence—about 3½ feet above ground and used that for his ham antenna."

"That just goes to show that you can't keep a good ham off the air," said Pendergast, as he carefully placed the letters on the operating desk.

"That's right," I replied. "I agree its hard to be loud on a city lot, but it can be done."

"Anything of interest coming up in the next month or so?," asked Pendergast.

"Well, yes," I said. "During the past winter season, there's been some amazing DX work going on on 80 meter s.s.b. Fellows on the west coast have been working into deep Europe and the near East via the *long path!* The openings are quite short, just for 30 or 45 minutes around sunrise on the U.S. west coast. That means the signals travel a sunrise-sunset path across New Zealand, up across Arabia, and through eastern Europe into Finland. The path is very narrow, no English or French stations heard to the west, and no Russian signals to the east. The path seems to go right through Czechoslovakia and up into Finland. Signals are *very* weak and it takes a *good* antenna, a *good* location, a *good* operator, a very quiet band and some degree of luck. I'd like to hear from some of the fellows working the DX, and I'd like to discuss their antennas and their opinion of the propagation path. The usual rules: for each letter used, a free copy of one of my handbooks."

"80 meters to Europe the long path, hey?," said Pendergast. "That must really separate the men from the boys!" ■

antennas

BY WILLIAM I. ORR,* W6SAI

"*Aloha!*" exclaimed Pendergast sliding easily into my favorite chair. He placed his feet on the operating table, knocking a pile of unanswered QSL cards into the wastebasket. "How was your vacation in Hawaii?"

I carefully fished the cards out of the basket and replied, "It was *great*. I wish I was still over there! In addition to sun and sand and those great *mai tais*, there was plenty of DX. What more could you wish?"

"I know all about the sun and sand and *mai-tais*," replied Pendergast. "How about telling me about the DX? Did you take a rig over with you?"

"Yes," I replied, "I took a transceiver along. We were in a condominium apartment and I erected an antenna inside the building."

"Inside the building?" repeated my friend. "That sounds interesting. Tell old Pendergast all about it."

"Well, Old Pendergast, the apartment was a frame building with a heavy shingle roof. We were on the second floor, and the peak of the roof was about 28 feet above ground. I didn't want to risk any problems with the manager, so I put the antenna up inside the building. The antenna ran from the front of the living room, up to the peak of the roof, then down to the rear of the bedroom...something like this (fig. 1). I had to drill a tiny hole in the wall at the top to get the wire through, but nobody will ever notice that!"

Pendergast looked at the sketch. "The ends of the antenna don't look very high," he objected.

"Only about 18 feet," I replied. "But let me tell you about the antenna. I think I had a pretty good solution to a difficult problem that a lot of fellows may be up against."

"Very good," said Pendergast, as he took his notebook out of his jacket and prepared to take notes.

"The overall dimension I had to work with was just about 45 feet. I wanted to work 80, 40 and 20 meters. From experience at other portable locations, I felt that a balanced, center-fed antenna system was the best choice from the TVI standpoint, as an end-fed job can sometimes get you into trouble when the electrical wiring of the building is coupled into the ground return system of the antenna. A 20 meter dipole would easily fit into the 45 foot space, so that was chosen as the basic antenna element. I used a ferrite core balun with it and a random length of RG-58/U light-duty coaxial cable."

"What about 40 and 80 meters?" asked Pendergast.

"Well, let's take 40 meters first. I decided that I could add extension tips and tuned traps to make the antenna into a 40 meter radiator. This would provide me with operation on 40 and 20 meters. Before I left on vacation, I strung a test antenna up in my back yard at about the same height I would have in the apartment and ran a set of s.w.r. curves on it. The antenna is shown in fig. 2, trap construc-

*48 Campbell Lane, Menlo Park, CA 94025.

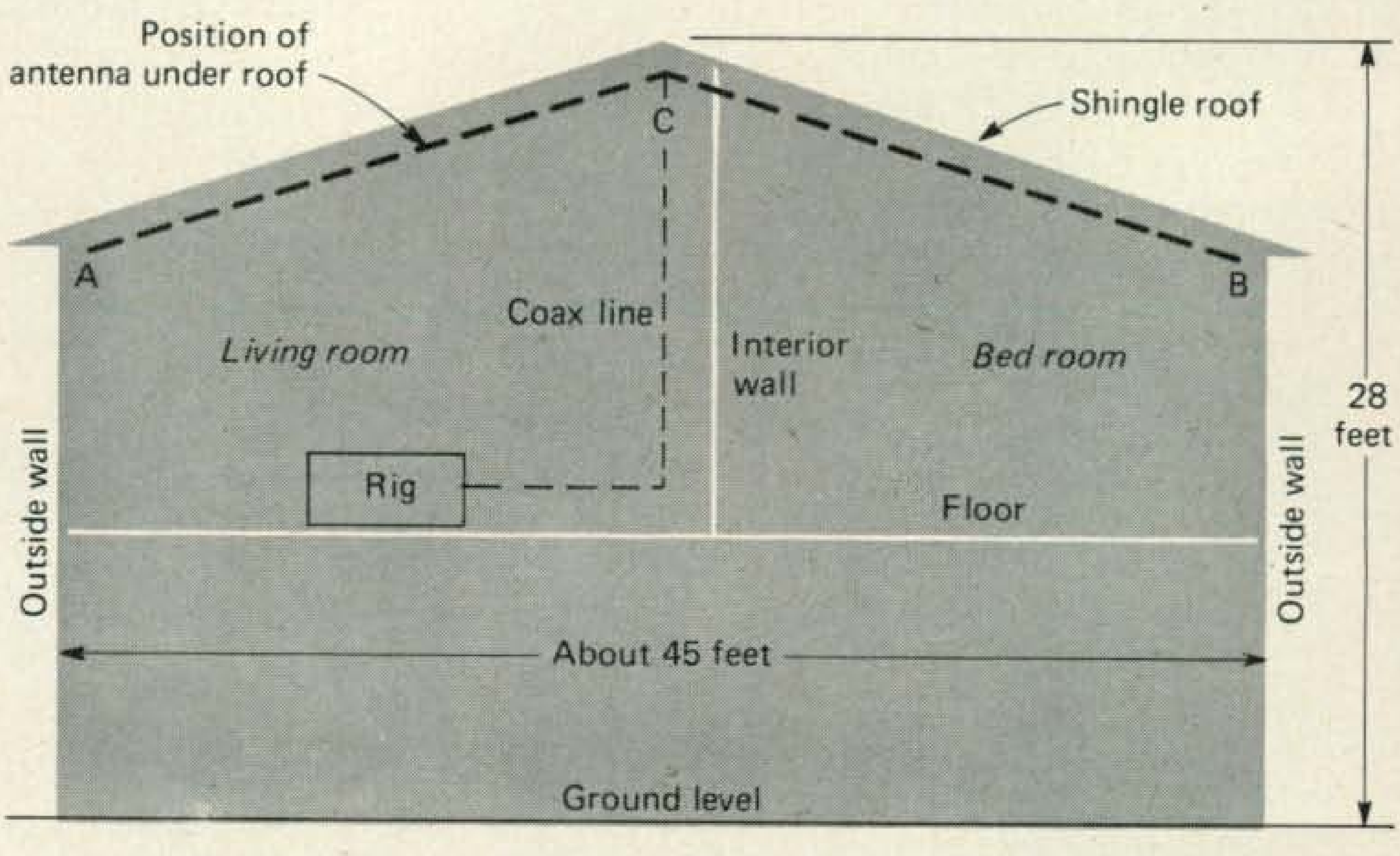


Fig. 1—Simplified elevation view of two story apartment building. Wood frame construction is used and roof is composed of shingles on tar paper and wood backing. The experimental antenna was slung between points A-B-C, with the balun at high point C. A small hole was drilled in the wall between the living room and the bedroom just below the roof so that the antenna wire could pass from the front to the back of the house. Point C is about 28 feet above ground level and points A and B are about 18 feet above ground level.

tion is shown in fig. 3 and the resulting s.w.r. curves are shown in fig. 4. As you can see, the s.w.r. was below 2-to-1 for most of the 20 meter band and below 3-to-1 from 7.1 MHz to 7.3 MHz."

"Can you shift the resonant points of the s.w.r. curves back and forth?" asked Pendergast. "I can see you are a phone man, or appliance operator. What would a *real* ham—a c.w. operator—do about the antenna?"

"If you are so smart, why don't you design the antenna yourself?" I asked. When Pendergast did not reply, I continued.

"You can shift the resonant points anywhere in the band you wish, provided you build the traps correctly. A trap acts as an insulator, or high impedance circuit, on the higher band (20 meters) and as a form of loading coil on the lower band (40 meters). The traps should be self-resonant *lower* that the lowest operating frequency you wish to use on the higher band. Since I wanted to be able to work down to 14.0 MHz, the traps are self-resonant at about 13.9 MHz.

"The first thing you do is to build the traps. Mine are made out of pre-wound, commercial coil stock and a high voltage ceramic capacitor. Resonance is established with the aid of a grid-dip meter and a calibrated receiver. A fraction of a turn at a time is removed from the coil until the trap resonates at the desired frequency. You start out with a few extra turns on the coil and remove them, a half-turn at a time, then a quarter-turn at a time, until you sneak up on the resonant frequency. Grid-dip the trap by itself, in a clear space, with no metal around. I used Millen grid-dip meter and could adjust the traps to within about 20 kHz of where I wanted them. If you are a perfectionist, you can bend the last turn on the coil back and forth and hit the target frequency on the nose."

"The traps don't seem to affect 20 meter operation in any way," mused Pendergast.

"No, they don't," I replied. "The 20 meter doublet works the same whether traps or glass insulators are used at the end, *provided* the trap is tuned outside the low end of the band. If the trap is tuned to a frequency *inside* the band, it seems to affect the length of the antenna."

"Amazing," murmured Pendergast. "Now, how about the 40 meter end sections?"

"Well," I replied," they are determined by the *heuristic* method."

"The *what*?" asked my friend.

"Cut-and-try," I answered." Luckily, a lot of information abounds in various Handbooks and magazine articles on 20-40 meter trap dipoles. I chose a set of tip dimensions from my Handbook *"Wire Antennas for Radio Amateurs"* and they worked right off; on the nose 100 per-cent!

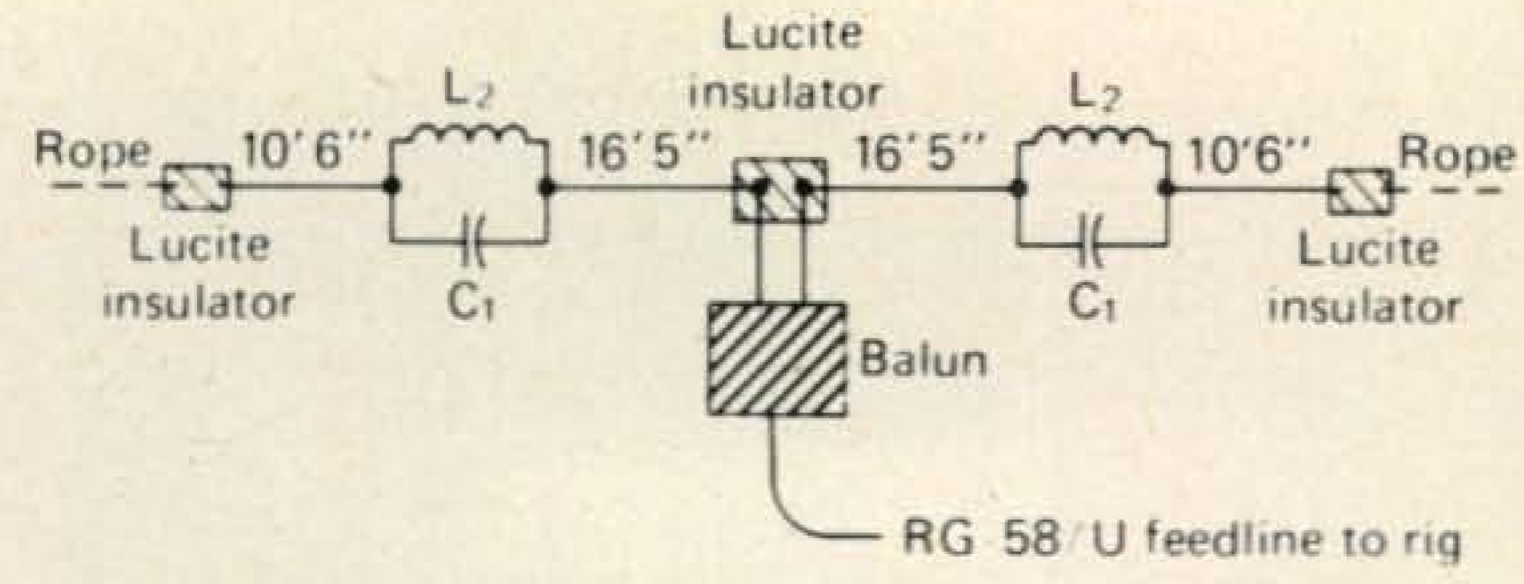
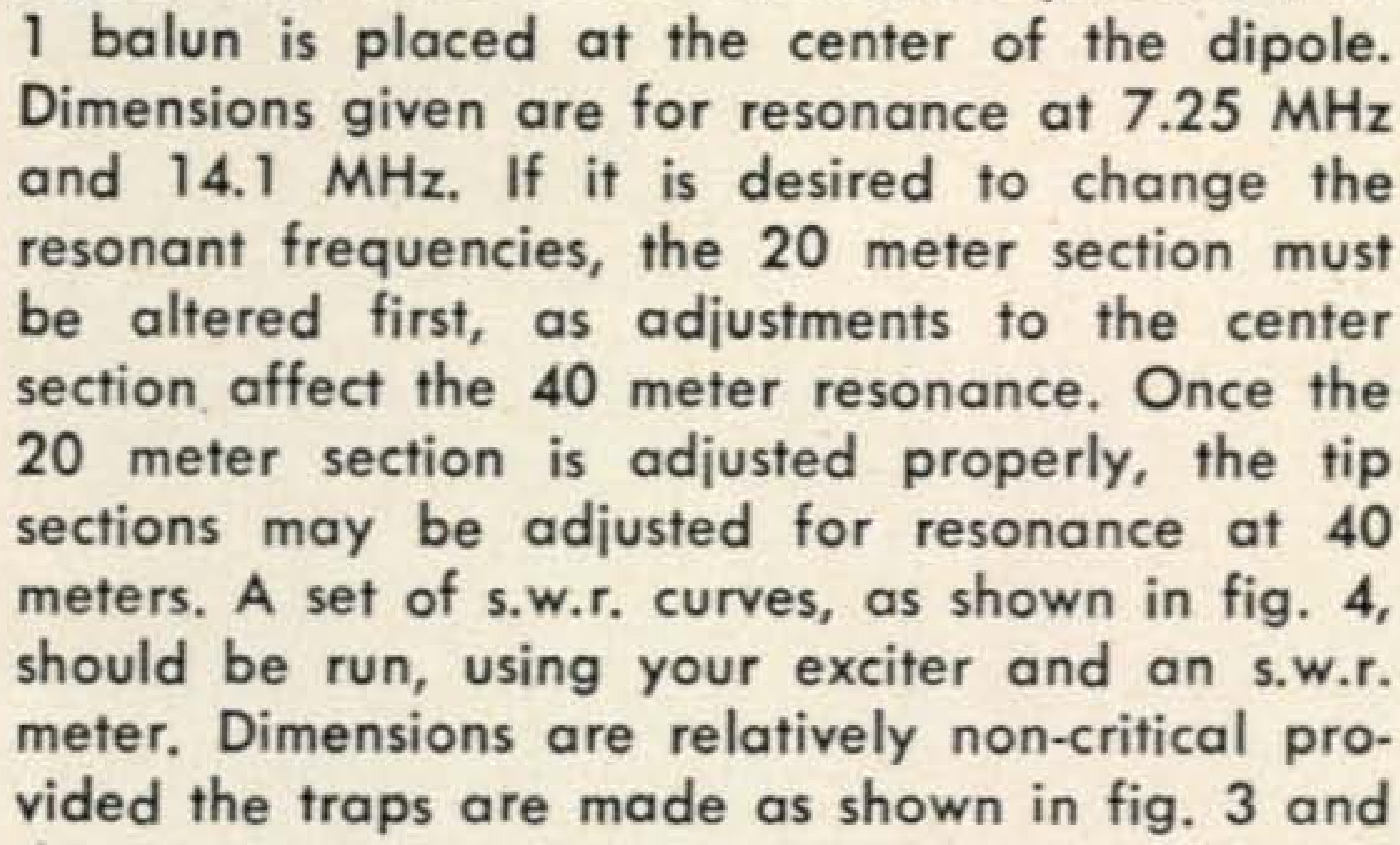


Fig. 2—The 40-20 meter two-band dipole. A 1-to-1 balun is placed at the center of the dipole. Dimensions given are for resonance at 7.25 MHz and 14.1 MHz. If it is desired to change the resonant frequencies, the 20 meter section must be altered first, as adjustments to the center section affect the 40 meter resonance. Once the 20 meter section is adjusted properly, the tip sections may be adjusted for resonance at 40 meters. A set of s.w.r. curves, as shown in fig. 4, should be run, using your exciter and an s.w.r. meter. Dimensions are relatively non-critical provided the traps are made as shown in fig. 3 and the antenna is erected reasonably clear of metallic objects. This antenna was built and tested in the backyard, in the clear, and then moved to the interior location shown in fig. 1 with very little change in the s.w.r. curves. A Bird #43 Reflectometer was used for tests. The balun was a ferrite design described by the author on page 66 of the February, 1975 CQ.



Notes:

C_1 = 25pf, 7.5 kV centralab type 850S.

L_1 = 9 turns no. 12, 2½" ID, 1½" long, 6TPI (B & W 3905 – 1 or I-Core 2006)

Fig. 3—The 20 meter trap. The coil and capacitor are suspended by their leads from a small insulator cut from a length of lucite rod. It is drilled for 6-32 bolts at each end. Antenna wires are wrapped around the bolts. The trap is assembled and grid-dipped to 13.9 MHz. Adjustment is made by making the coil a little too big and then removing turns, a portion of a turn at a time, until the assembly is self-resonant at the desired frequency. Two traps are required. Once they are adjusted on the bench, they can be put in the antenna and no more adjustments are required to these units. Diameter and turns-per-inch of coil are not critical as long as completed assembly tunes to the desired frequency. Manufactured pre-wound coil stock (I-Core or B&W) is very suitable for trap assembly. These inductors are available from Barry Electronics, 512 Broadway, New York, N.Y. 10012.

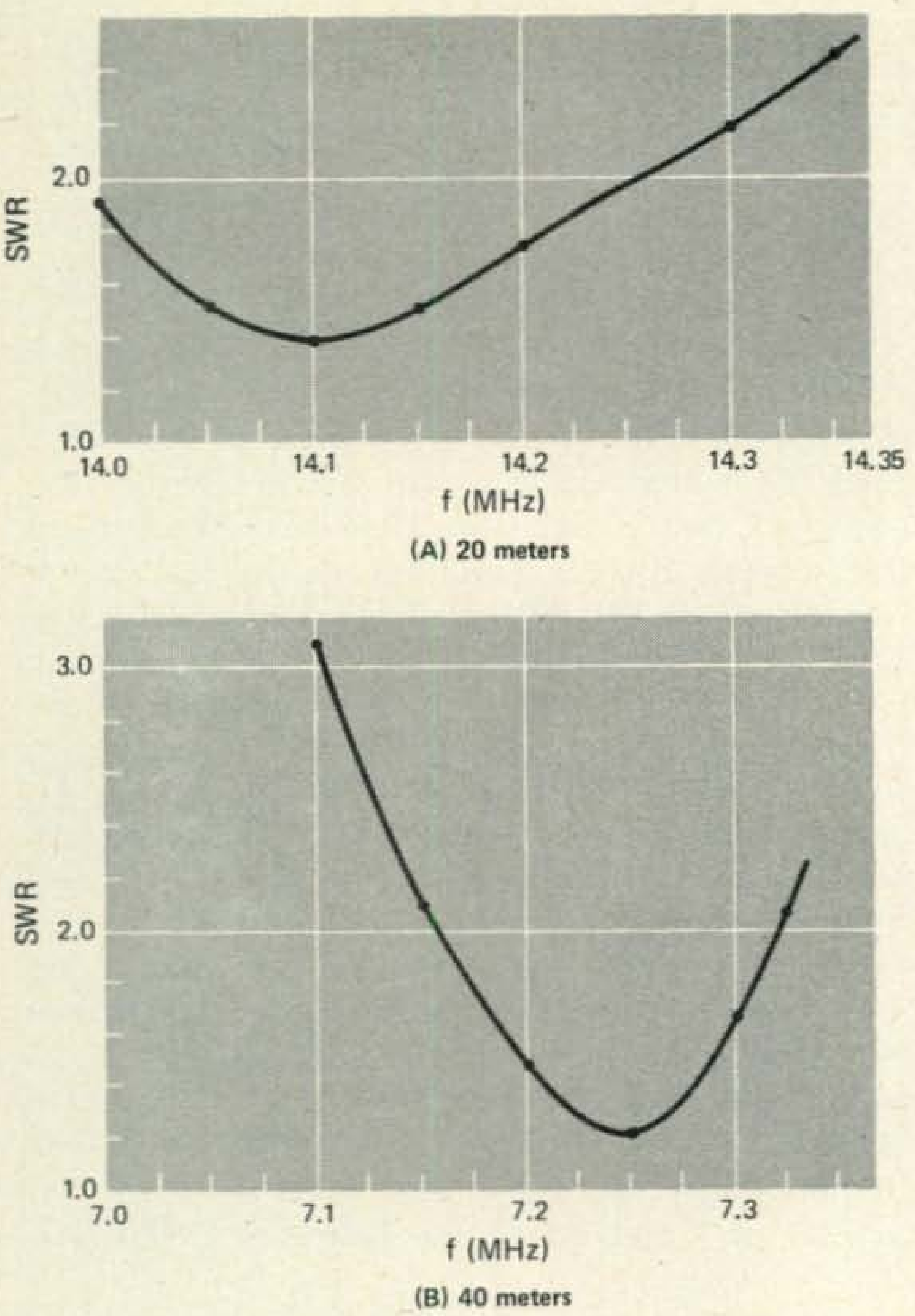


Fig. 4—S.w.r. curves for the antenna of fig. 2. The 20 meter section was cut for 14.1 MHz and the 40 meter section for 7.25 MHz. To lower the resinance of the 40 meter section, the tip sections of the antenna should be lengthened a few inches.

"And, as an added bonus, this antenna also works on 15 and 10 meters," I continued. "It works on the third harmonic of the 40 meter dipole for 15 meters and also exhibits a low value of SWR on 10 meters, although the actual operation of the antenna on 10 meters is a more complex matter. So there you have it—an antenna system for 40, 20, 15 and 10 meters that is only about 55 feet long!"

Pendergast scribbed furiously in his notebook. "Very good," he exclaimed. "Now, how about operation on 80 meters?"

"That can be accomplished," I replied, "With certain reservations. Attend! You can work the antenna on 80 meters if you remove the traps and substitute loading coils in place of the traps. You now have a loaded dipole instead of a trap antenna. However, you must understand what is going on before you rush headlong and make the change."

"How do you make the change?" asked Pendergast.

"Well, in this case the antenna was indoors, and wasn't very high above the floor of the second story apartment. My traps were mounted in place with bolts and wing-nuts. I merely removed the nuts, slipped the traps off, and substituted the loading coils in their place. I stood on a chair to do it, and it took about 2 minutes to do the job."

I reached for Pendergast's notebook and drew a picture of the revised 80 meter dipole (fig. 5).

"What's the extra coil in the center?" asked Pendergast.

"One thing at a time, I replied." This is an 80 meter dipole, loaded with coils on each side. For highest efficiency, the coils are very high-Q. They are bolted in place of the traps, as you can see in the illustration.

"The antenna is quite short for 80 meters and, as you know, short antennas have very low radiation resistance. Also, this antenna is going to be mounted very close to the ground. I estimated the radiation resistance would be about 12 ohms, or even less. In addition, I measured the Q of the coils. It was about 350. The coils each have a reactance of around 1400 ohms at the design frequency of 3.8 MHz, so the loss resistance of each coil is 1400/350, or about 4 ohms per coil. Since there are two coils, the loss resistance is the sum, or 8 ohms. Then, there's going to be some more loss resistance introduced by nearby objects when I mount the antenna inside the wood frame building. The total input resistance, then, at the center terminals of the dipole is thus going to be 12 + 8, or 20 ohms, or maybe a little lower."

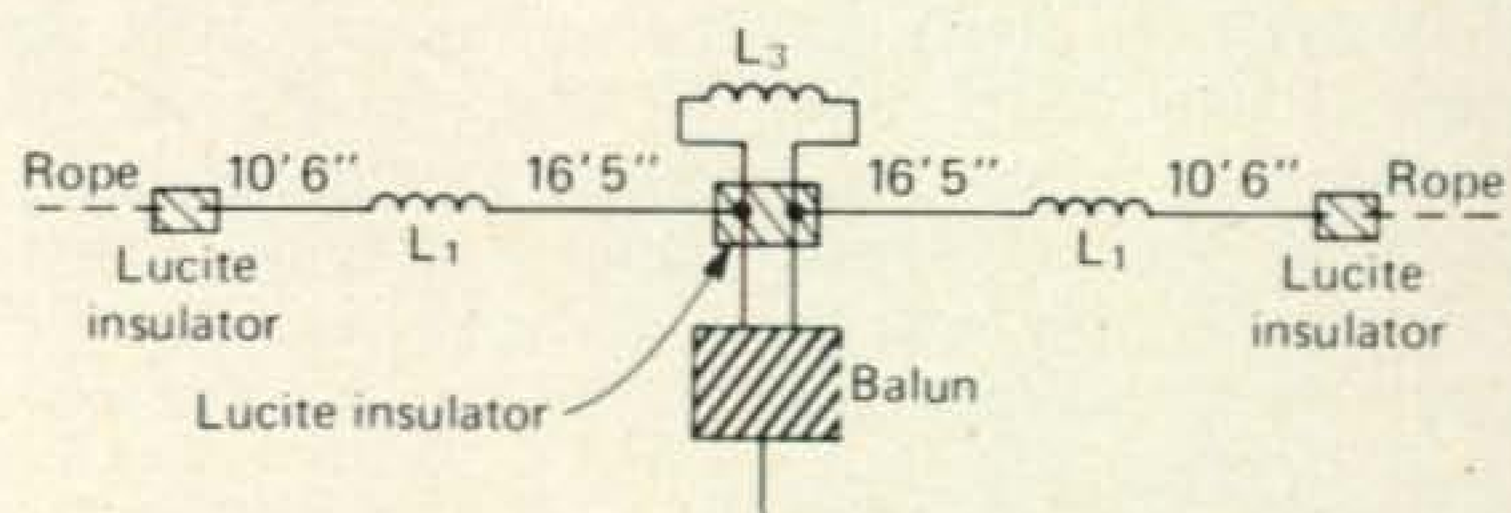


Fig. 5—The 40-20 meter two-band dipole of fig. 2 is reworked for 80 meter operation. Traps L_1-C_1 are removed and loading coil L_2 consists of 38 to 43 turns, 3" diameter, ten turns per inch of I-Core inductor. Approximate inductance is 50 microhenries. Using the above wire lengths, 43 turns resonate at 3.5 MHz, 40 turns for 3.68 MHz, and 39 turns for 3.73 MHz. An end turn of each coil can be trimmed to "zero-in" on a chosen design frequency. In order to raise the feed point impedance, a matching coil L_3 is placed across the feed point. The coil consists of 12 turns, 6 turns per inch, 1¼" diameter (about 2.0 microhenries). All coils are wound with #14 gauge wire. When the 20 meter traps are substituted for the loading coils (to go back to 40/20 meter operation) the matching coil L_3 is left in the circuit as it has little effect on the higher frequency bands.

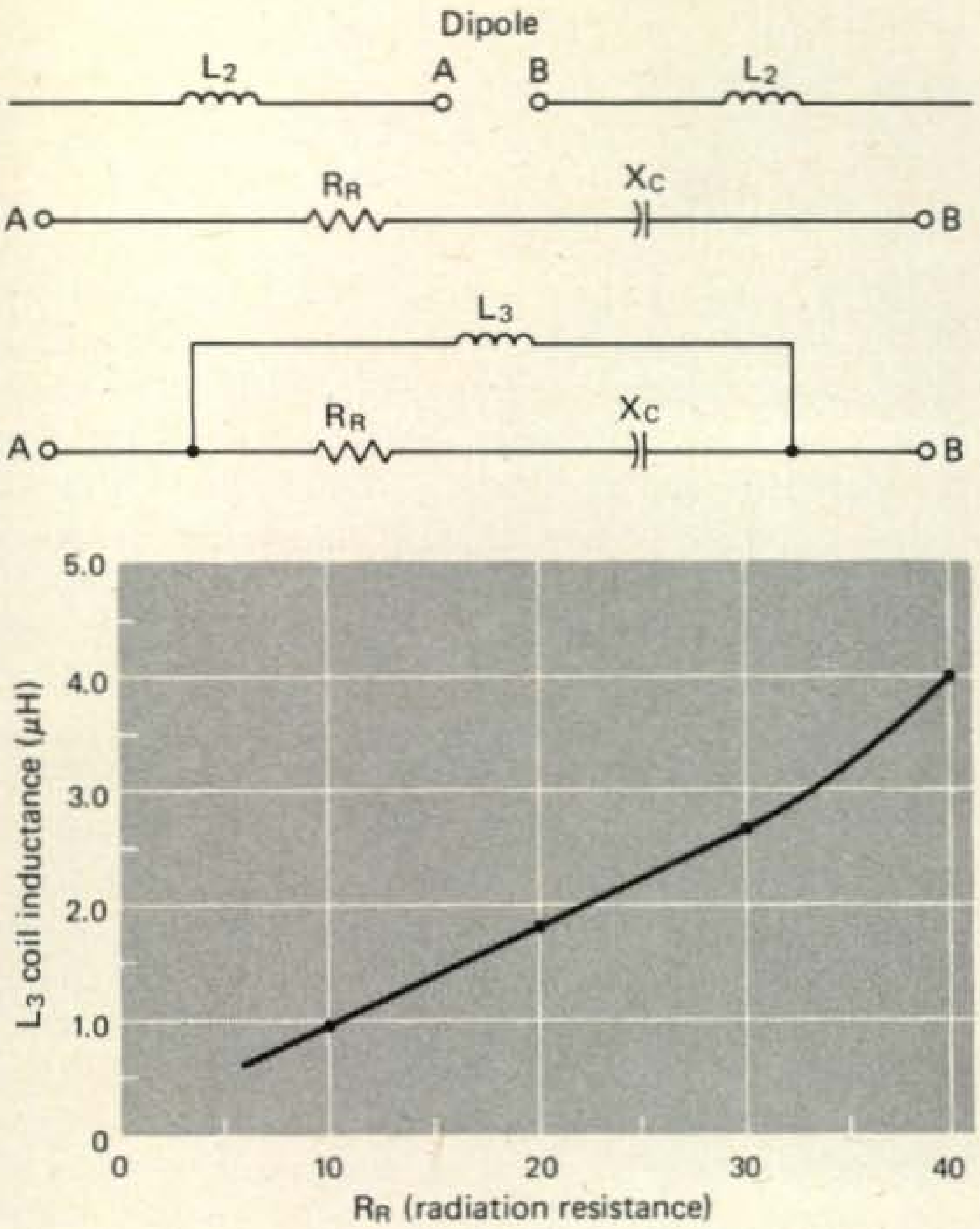


Fig. 6—The dipole element can form a portion of a network whose input impedance over a small range of frequencies is close to 50 ohms. The dipole element, when loaded, as shown in the top illustration, has a low value of radiation resistance and loss resistance whose sum is a function of the degree of loading (and the overall length of the antenna). This low impedance can be made a part of an equivalent parallel resonant circuit in which the total radiation resistance appears in series with the reactive branch of the circuit (center illustration). The input impedance of such a circuit varies nearly inversely with respect to the radiation resistance R_R of the dipole, thus the very low value of radiation resistance of a loaded dipole may be transformed to a larger value which will match the impedance of the transmission line (lower illustration). The radiation resistance of the dipole can be made to appear as a capacitive reactance at the driving point by slightly shortening the element past its normal resonant length. The inductor (L_3) consists of a small coil placed across the terminals of the dipole. The L/C ratio determines the transformation ratio of the network. Typical values for L_3 are shown in the graph for 80 meter operation.

"Well, with a 50 ohm line, you are in trouble," said Pendergast. "The s.w.r. on the line will be no better than 2-to-1 at the resonant frequency, and will be worse off-frequency."

"You are so right," I replied. And since the antenna is very short, the operating bandwidth is going to be small, so the s.w.r. is going to go up rather rapidly when the antenna is operated off-frequency."

"What is needed is a matching network that will match the 50 ohm transmission line to the 20 ohm antenna. And that's where the center coil comes in. It is placed right across the balun terminals."

"That doesn't look like an impedance matching network to me," objected Pendergast.

"Aha, it is," I replied. "Look at fig. 6. This is a simple, balanced L-network.

The capacity, in this case, is provided by the antenna element, because *if* the antenna is shorter than resonance, it provides a capacitive reactance across the terminals."

"You mean you deliberately detune the loaded dipole a bit so as to provide a capacitive load?" asked Pendergast.

"That's right," I replied. "The whole idea is non-critical. For this antenna, the coil is about 2 microhenries. I didn't even attempt to detune the antenna, because all that happens is that the resonant frequency of the antenna is shifted a bit from the normal value when the center coil is inserted, and the trimming action to shorten the antenna merely re-establishes resonance. Since the whole antenna is cut-and-try, I decided to just add the coil and see what the results were. The first try resulted in an s.w.r. of about 1.5-to-1. I took one turn off the center coil to readjust the impedance match a bit and *voila!*. The s.w.r. at resonance was about 1.2-to-1 (fig. 7). The bandwidth at the 2.5-to-1 s.w.r. points was about 40 kHz."

"Pretty neat," admitted Pendergast "How did you adjust the loading coils?"

"You can zero-in by lowering the antenna until you can reach the center coil with a grid-

[*Continued on page 66*]

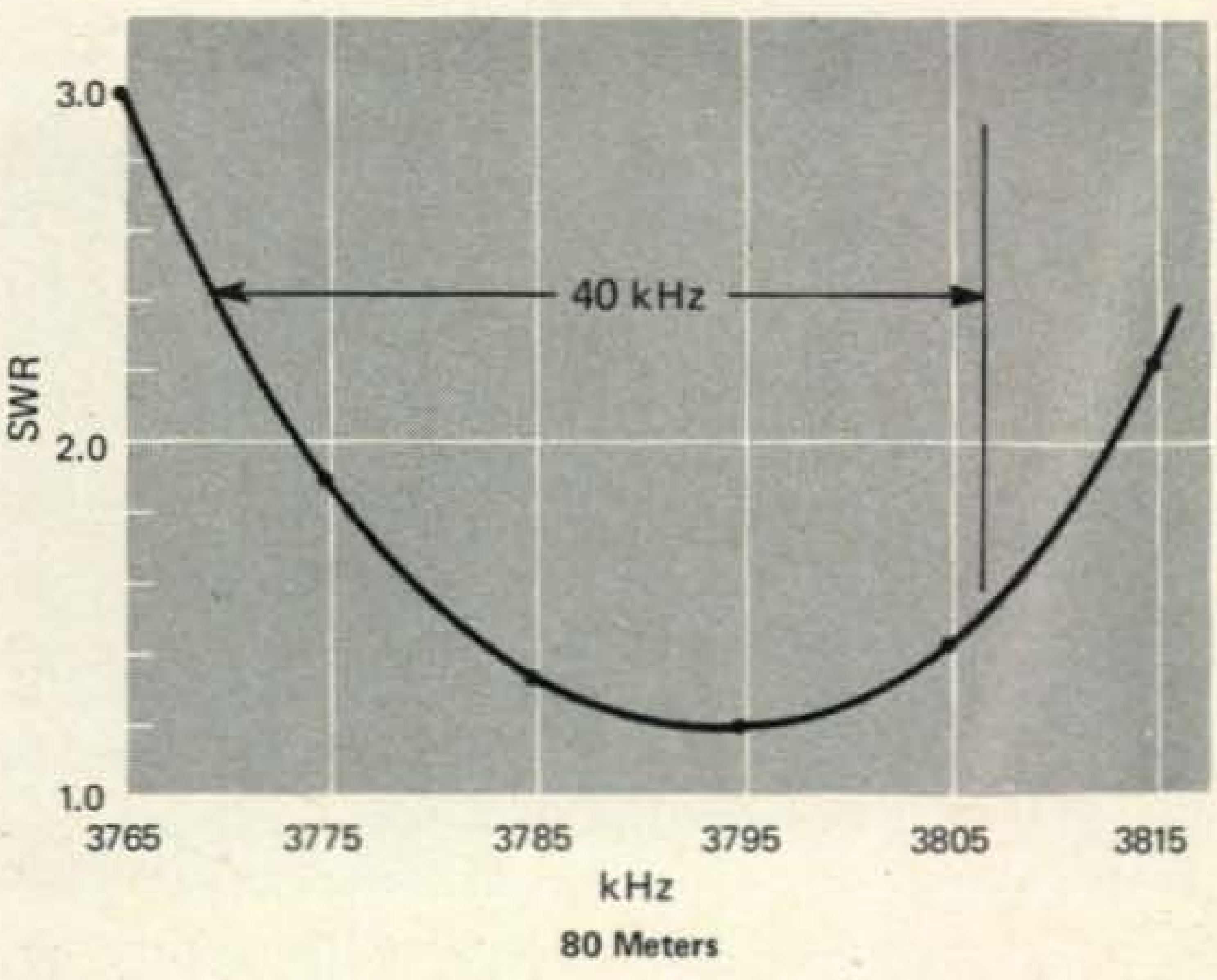


Fig. 7—The s.w.r. response of the loaded 80 meter dipole of fig. 5. Bandwidth between the 2.5 s.w.r. points is just about 40 kHz. S.w.r. at resonance (3787 kHz) is 1.2-to-1. It was desired to move the resonant frequency up to 3805 kHz and this was done by removing 3 inches of wire from each tip of the dipole.

Math's Notes [*from page 49*]

RT-70/GRC used in good condition with all tubes	$22.95
Handset H-33/PT with attached plug for the RT-70	5.95
Mating power connector	2.50
Instruction Manual TM11-290	5.00

We will be happy to supply exact conversion details after we have modified our unit along the lines indicated if we have enough interest and are most anxious to hear from other amateurs who either have or are planning to do a more elaborate conversion on this unit.

73, Irv, WA2NDM

QRP [*from page 46*]

one weekend with the HW-7. I also plan to take it to VP2M land in a few weeks and operate from VP2MHK." . . . **Duane E. Gardner, WN3TPN,** 467 Lois Drive, Pittsburgh PA 15236: "First of all, I have been working on WAS since receiving my Novice Ticket a year ago and had 44 states confirmed inside of three months with the exception of RI. I borrowed a TenTec Power Mite 5 watt transceiver from a friend while my HW-16 was down for repairs and within a week I'd added RI to the confirmed list. I have made many long distance contacts and have had some fine QSO's with hams in TX, FLA, WIS, etc., with 589 and 599 reports with just five watts, which is as well as I do with the 75 watt HW-16. I use an inverted V and just last night had a great QSO with another Novice in TX (a QRPp'r also, by the way) for almost an hour on 40m. Seems that when I tell a contact that I am using a QRPp rig, I get a 'hi hi' and sure enough he is also, only usually with less "watt-power" than me. Very interesting. How can you tell a QRPp rig from a QRO rig? Nuff said from this end. Keep up the good work."

Other Tidbits

The QRPp Net (3540 kHz, Tuesdays, 2200 EST) has been going quite well. On quiet nights we've been getting up to a dozen checkins with contacts all over. Probably 80 will be dead by the time this appears in print. As noted last month, let's go to 20 meters (Saturdays, 1600Z, 14065 kHz).

A QRPp Club is now underway in England. Write to G. C. Dobbs, G3RJV, 61 Park St., Cleethorpes, S, Humberside, England, for details. Membership open world-wide.

The QRPp WAS and DXCC standings can be found elsewhere. I want to thank all of you who have submitted your standings so that we can present a broad picture of QRPp activity. Till next time, have a good Field Day and drop your entries for the Milliwatt Field Day Trophy to me (copy of ARRL entry form, description of rig and power, check-sheet).

73, Ade, K8EEG

Antennas [*from page 43*]

dip meter. Then, with the feedline removed, adjust the loading coils until the antenna dips where you want it. This entails a bit of fiddling around. However, the 1975 edition of the ARRL *Antenna Book* (13th edition), page 212 has a very handy chart for loading coils which gets you in the ball-park. I followed their information, made the coils about 5 turns too big, and then proceeded to trim the coils, grid-dipping the antenna until I was just about where I wanted to be. Then I raised the antenna in the air, ran an s.w.r. curve on it, and trimmed the coils a fraction of a turn. I found that removing a single turn from each coil changed the 80 meter resonant frequency about 50 kHz, and trimming an inch from each end of the antenna changed the resonant frequency about 10 kHz.

"But you are stuck with the narrow bandwidth no matter what you do. Even so, an operational range of 40 kHz is still enough to work plenty of stations. I centered my antenna at 3.8 MHz."

"Well, since you pre-cut your antenna at home, how did it work in Hawaii?" asked Pendergast.

"Plenty good," I replied. "I worked 6W8DY in Senegal on 80 meter s.s.b. with the antenna mounted in the apartment, using my transceiver. I don't know who was more surprised, the 6W8 or myself! And from KH6 to 6W8 is a *long, long way on any band!*"

"Congratulations," said Pendergast. "That proves the old saying. DX is 90% operator and 10% antenna."

"Thanks," I said. "I guess that's a compliment." ■

[EDITOR'S NOTE: More on this interesting antenna next month.

Power Limits [*from page 39*]

There will, of course, be those who will obtain a few more watts and minimize short tube life by reducing filament power during stand-by, and increasing filament power during r.f. drive conditions, or increasing plate voltage, to maximize plate efficiencies. But, as the old saying goes, "you can't get something for nothing," and equipment and tube manufacturers can tell upon inspection if their product has been abused. One or two db would not be worth the effort.

Presently it is very difficult, if not impossible, for the FCC to monitor and police amateur power limits. By using this technique, if an amateur amplifier were hooked up and using

antennas

BY WILLIAM I. ORR,* W6SAI

"You foxy fellow," exclaimed Pendergast. "You didn't tell me everything about the multiband dipole that you described in the June issue of *CQ*. "You are holding things back."

"Well, there is more to it," I admitted. "The design I described was a center-fed antenna having an overall length of about 55 feet, including the insulators (fig. 1). The antenna wire was broken at points equidistant from the center for the inclusion of matching networks. With a pair of tuned traps, the antenna provided resonance on 40 and 20 meters, and with a pair of loading coils (L_3) the antenna provided operation over a narrow segment of the 80 meter band.

"Since the antenna is quite small compared to an 80 meter dipole, the impedance at the feedpoint in the center is quite low and some form of matching network is required. A simple matching coil (L_4) placed across the antenna feedpoint does the trick, bringing the impedance that the balun and transmission line 'look into' to about 50 ohms.

"When the traps are used, the operational bandwidth, that is, the bandwidth between the 2 to 1 s.w.r. points, covers the 20 meter band, and covers about half of the 40 meter band. For 80 meter operation the bandwidth, under the same conditions, is about 40 kHz."

"That's right," interrupted Pendergast. "All this information is discussed in your June article, in detail. But I understand that it is possible to achieve good 20 meter operation with the 80 meter loaded dipole. Is that correct? You didn't mention *that* in your article."

"*No*, I didn't mention it, and *yes*, you are correct," I replied.

"Interestingly enough, the 80 meter loading coils act somewhat as high impedance r.f. chokes at 20 meters, providing an excellent degree of isolation between the outer tips of the antenna and the inner, 20 meter dipole portion. The coil is about 63 microhenries. . . ."

"Your June article said 50 microhenries," said Pendergast stiffly.

*48 Campbell Lane, Menlo Park, CA 94025.

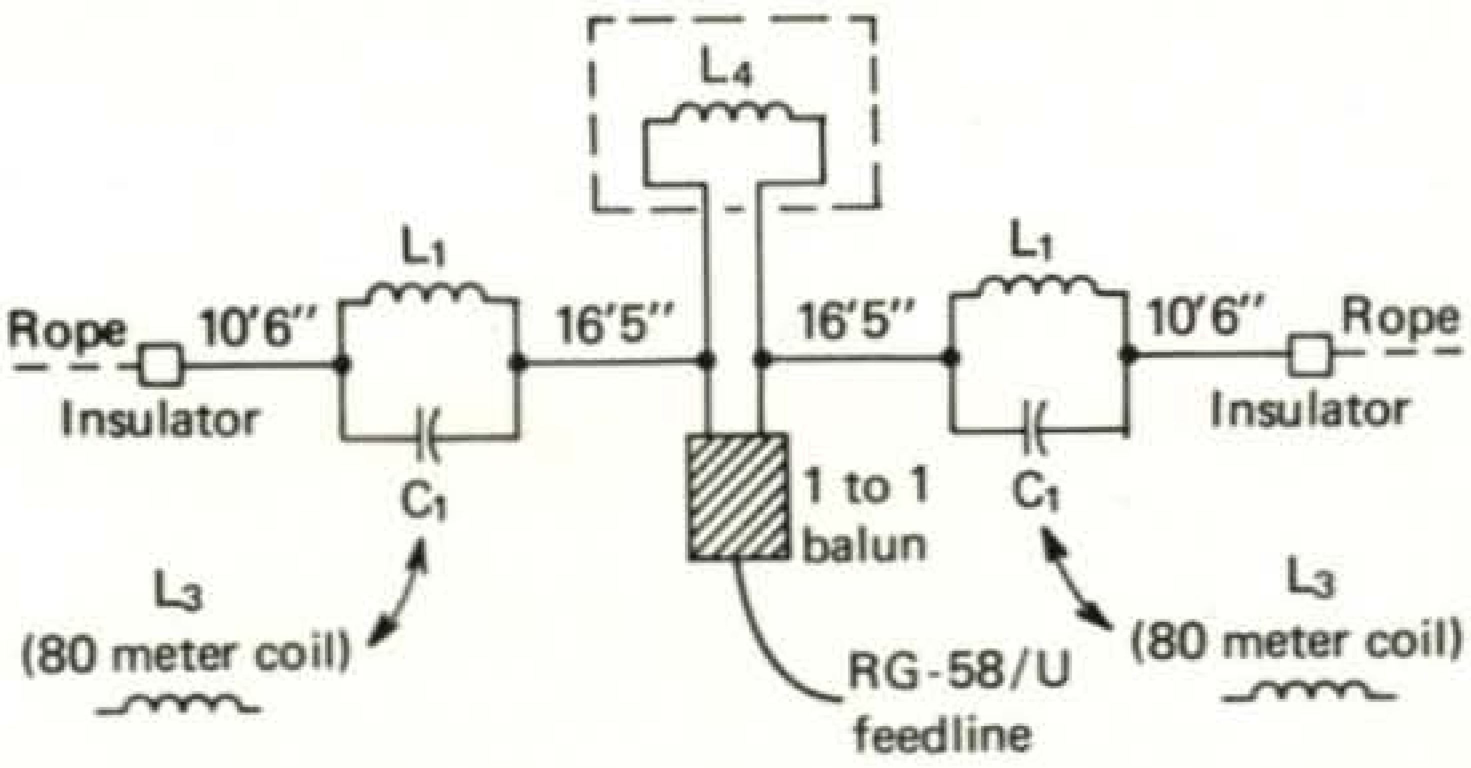


Fig. 1—The 40-20 meter trapped, two-band dipole. A 1-to-1 balun is placed at the feedpoint. Dimensions are given for resonance at 7.25 MHz and 14.1 MHz. If the tuned traps (L_1-C_1) are removed and loading coil L_3 substituted in each case, the antenna is sharply resonant in the 80 meter band. As this article explains, the 80 meter loaded dipole is also resonant on 20 meters. The 20-40 meter trap consists of a 9 turn coil, 2½" diameter and 1½" long wound of #12 wire (B&W 3905-1, or equivalent) in shunt with a 25 pf, 7.5 kv capacitor (Centralab type 850S). The trap is self-resonant at 13.9 MHz. The 80 meter loading coils (L_3) are 38 turns, 3" diameter, 10 turns per inch of #14 wire. The coils are trimmed for resonance at the desired 80 meter operating frequency. Bandwidth is about 40 kHz. The matching coil (L_4) consists of 12 turns, 6 turns per inch, 1¼" diameter of #14 gage wire. L_4 is trimmed, a turn at a time, for best s.w.r. at resonance on the 80 meter band. Antenna will also work well on 20 meters, as described in the text.

"That was a first-order guess," I replied. "Sixty-three microhenries is more nearly correct. The number of turns in the loading coils determined actual antenna resonance, and the number varies by about six turns in each coil from one end of the band to the other. But you distract me. Let's get back to 20 meter operation of the 80 meter antenna.

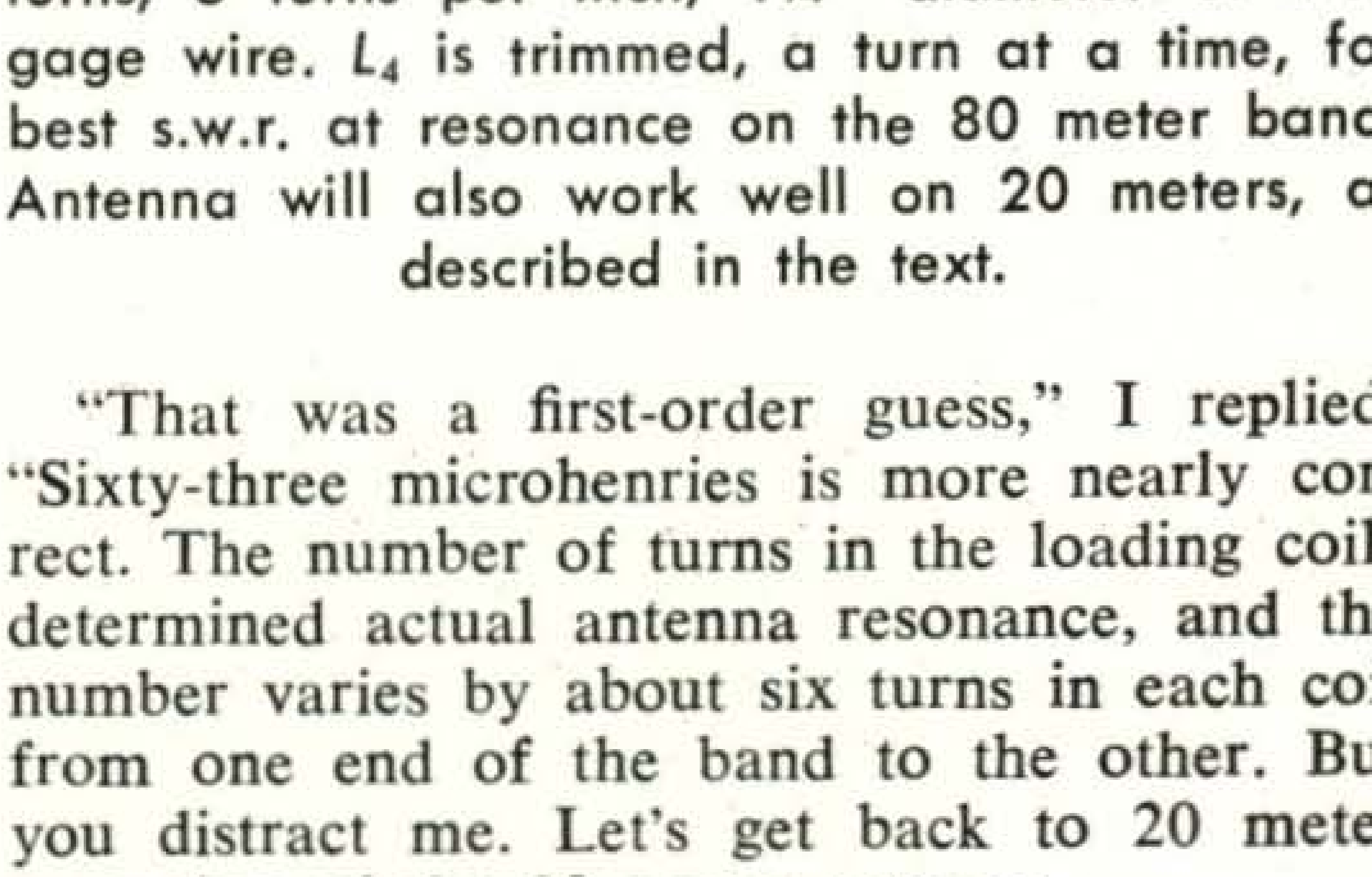


Fig. 2—Operation of 80 meter dipole on 20 meters compares favorably with operation of 20 meter dipole. The harmonic of the 80 meter loaded dipole falls very close to 14.0 MHz, as shown by the s.w.r. plot. This simple antenna, then, provides a choice of 80/20 or 40/20 meter operation by the use of either traps or loading coils. Not bad for a simple 55 foot long antenna!

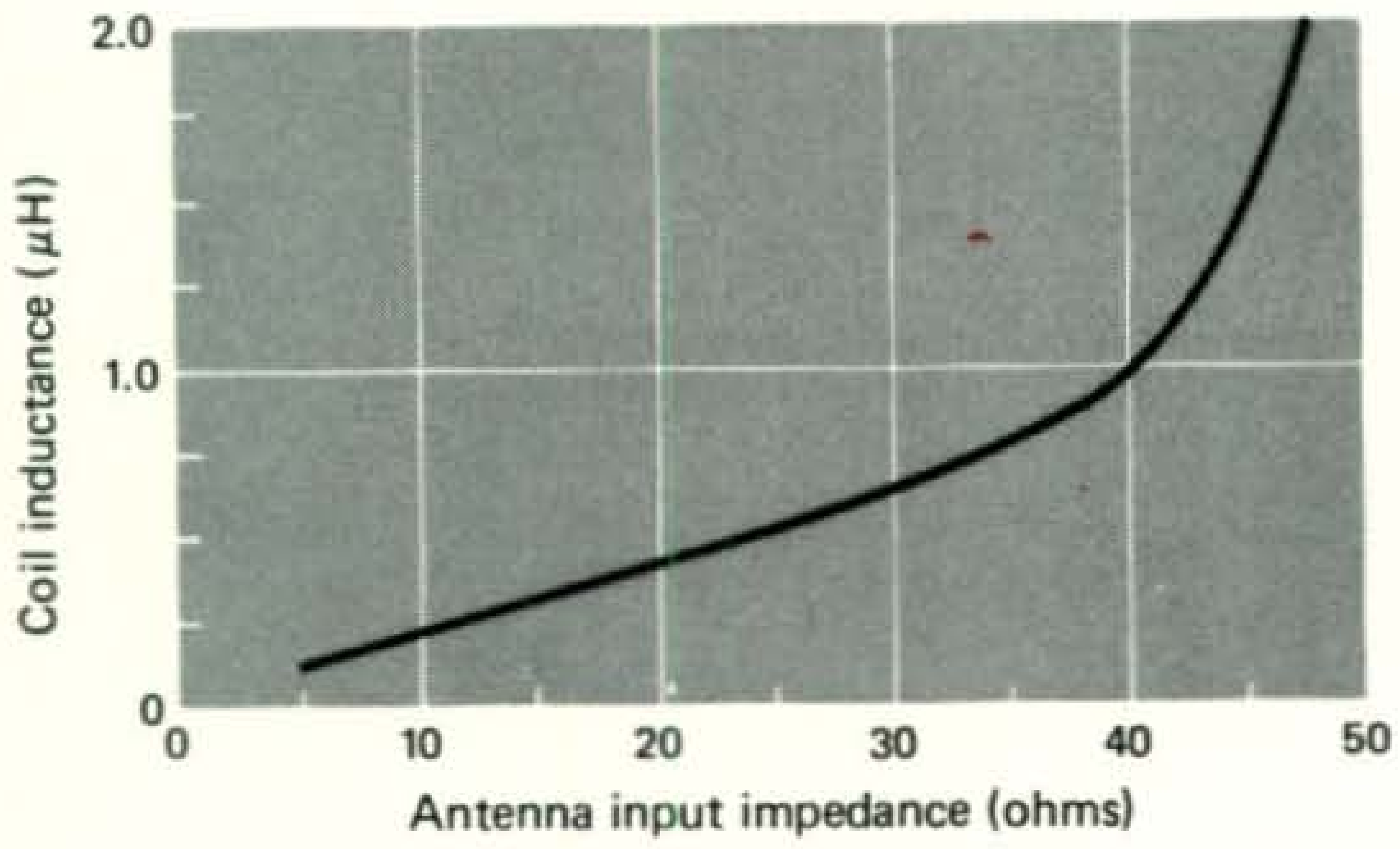


Fig. 3—Inductance of center impedance matching coil as a function of antenna input impedance. Start with maximum inductance in the coil and short out a turn at a time until lowest value of s.w.r. is achieved on the transmission line.

"The loading coils, as I have said, act as r.f chokes on frequencies higher than antenna resonance, and at some higher frequency, permit a second resonance to occur. The point of second resonance is a function of coil inductance and the length of the inner sections of the dipole. In this case, the inner sections were intentionally cut for 20 meters. Now, *if* the loading coils really act as r.f. chokes at 20 meters, you do in fact have a 20 meter dipole. And the s.w.r. measurements tend to prove just that (fig. 2). Here's a s.w.r. plot of the 20 meter dipole with the end sections disconnected and a plot of the operation of the 80 meter loaded dipole on 20 meters."

Pendergast looked closely at the sketch. "It looks to me as if the second-order resonant frequency of the loaded 80 meter antenna falls very close to 14.0 MHz," he stated.

"It certainly does," I replied. "By itself, the inner, 20 meter, portion of the antenna has a self-resonant frequency of about 14.1 MHz, so it looks as if the loading coils disturb the resonant frequency by only about 100 kHz. That's not bad.

"You'll note that the slope of the two s.w.r. curves is nearly identical, so the bandwidth of the two antenna types is just about the same."

"Was the 80 meter center impedance matching coil left in the circuit for 20 meter operation?", asked Pendergast.

"Yes," I replied. "I saw no reason to remove it. As you can see from the s.w.r. curves, the antenna exhibits a good s.w.r. curve on 20 meters. The little center matching coil doesn't affect 20 meter performance to any degree."

I reached up to the high bookshelf and took down a bound volume of *QSTs*. "Here's an interesting article by W4JRW in the April, 1961 issue of *QST*," I said. "It's entitled *'Multiband Antennas Using Loading Coils.'* The author describes a loaded 80 meter antenna that also resonates on 40 meters. He claims the idea is an old one, being described in the *Bureau of Standards Circular C74, Radio Instruments and Measurements,* published in 1924. The circular describes loaded antennas and states that 'the harmonic frequencies are no longer integral multiples of the fundamental, as in the case of the simple antenna.'

"W4JRW took that idea and used high inductance loading coils—about 120 microhenries—to make up a two-band dipole for 80 and 40 meter operation. He hinted that using "various lengths of wire" and "various values of coils" that antennas could be built for 80 and 20 meters, 80 and 15 meters and other such combinations."

"Did he show any designs of that type?" asked Pendergast.

"No," I replied. "And I must admit I had forgotten about the article. I only remembered it after I had tried the loaded 80 meter dipole on 20 meters. Then a bell rang, and I spent an

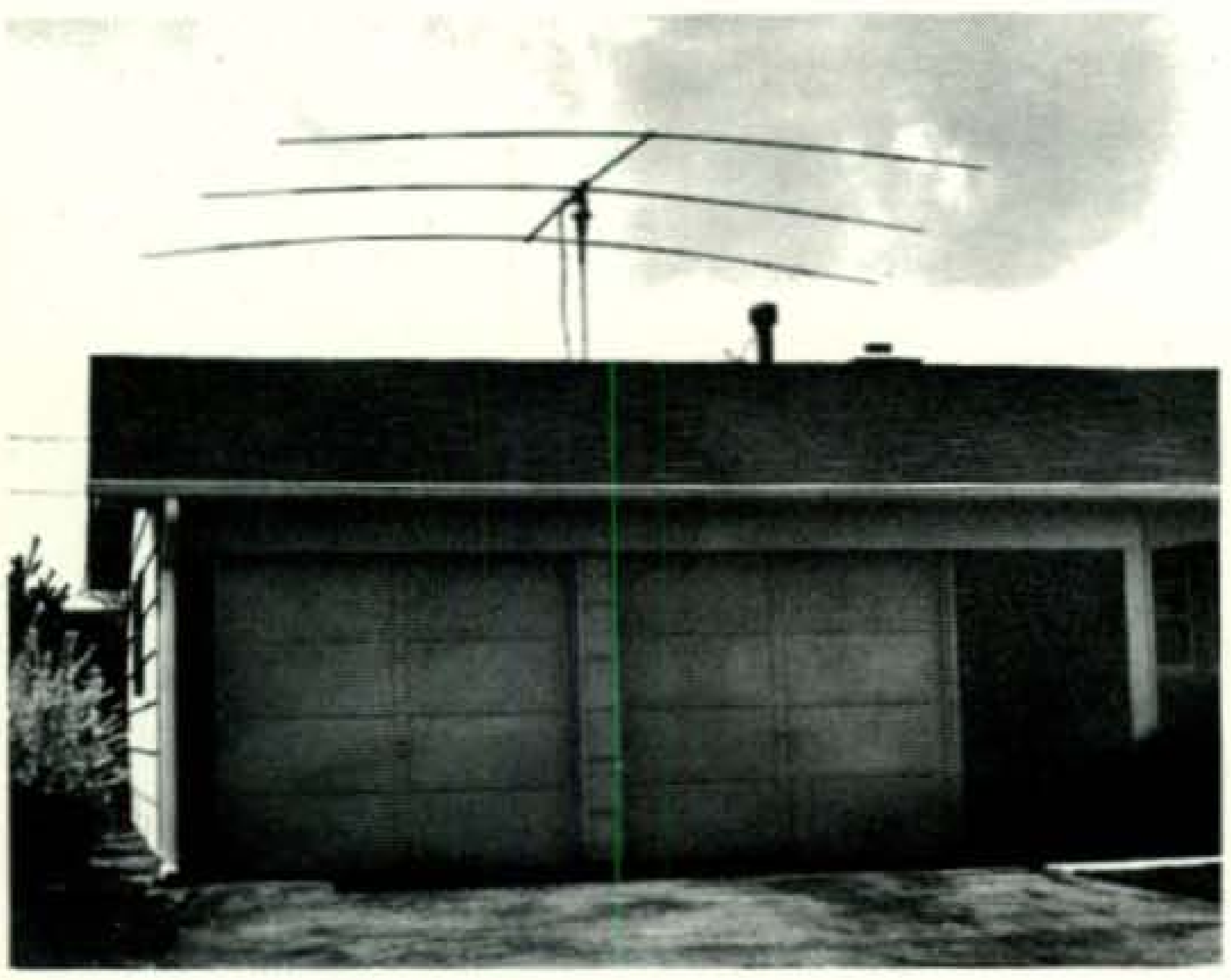


Fig. 4—The rotary beam antenna of WA3HDU. Tribander beam and rotor are mounted atop the mast, all set to work DX! But what if a neighbor complains the antenna is an eyesore?

Fig. 5—The disappearing antenna of WA3HDU. By means of a clever hoisting mechanism, WA3-HDU lowers his beam below rooftop when it is not in use.

hour or two looking through back issues of *QST* until I found the W4JRW article. So I guess I sort of re-invented the wheel."

"Well, that's interesting," said Pendergast, suppressing a yawn.

"I guess W4JRW beat you to the punch."

"Yes," I admitted. "Great minds think along the same channel."

"In any event," said Pendergast, "Between you and W4JRW, it has been proven that a loaded dipole can be made to work on two frequencies and that by proper placement and size of the loading coils, the two frequencies can be any two high frequency amateur bands, such as 80 and 40 meters, 80 and 20 meters, or the like."

"That's right," I replied. "I suggest you obtain the April, 1961 issue of *QST* and read the original article. There's a lot of food for thought in it. It may be possible to make up a compact, 80 meter beam—or to make a 20 meter beam work on 80 meters—by using this principle. Perhaps some smart lad will carry these little experiments further."

"Any remarks you would care to make about the center loading coil?" asked my friend as he made quick, pencil sketches in his notebook.

"Well," I replied, "This is a good matching scheme which is not well known among amateurs, although the idea is used every day in commercial practice. Take the case of the usual 80 meter dipole, or inverted-V antenna. In most cases, the antenna is quite close to the ground, in terms of wavelengths of height. A typical 80 meter dipole may be 30 feet in the air. That's equivalent to an electrical height of only 0.115 wavelength. At that low height the feed point impedance could be as low as 10 to 15 ohms, depending upon ground conduction. The fellow that erects an 80 meter dipole at a reasonable height, then, finds out that the s.w.r. curve on a 50 ohm transmission line is terrible. At resonance, the s.w.r. could be as high as 5 to 1, and it becomes even worse off-resonance."

Pendergast sniffed. "I have an 80 meter dipole about 40 feet high and the s.w.r. at resonance is about 1.5 to 1. I cut it for 3800 kHz." He paused a bit, then said, "I'll have to admit that loading it up is a tricky process and when I operate off-frequency, the loading on my transceiver seems very odd to me."

"Could be," I admitted. "The feed-point impedance figures given for a low dipole are either computed, or measured over a perfect ground. In a real-life situation, with an imperfect ground, and with nearby conducting objects, such as telephone and light lines, the input impedance could be something else again. A few years ago I made careful measurements on an 80 meter dipole that was about 35 feet high and came to the conclusion that the input impedance at resonance was about 20 ohms."

Fig. 6—Inside the garage the secret is exposed. WA3HDU has a periscope arrangement, driven by a cable and a winch. The mast is a section of 2" diameter aluminum tubing and the vertical travel is about 7 feet. A bushing in the ceiling of the garage and another in the roof steady the mast. Anti-rotation pins are built in the mast in the extended and retracted positions to prevent the mast from turning.

"Well," replied Pendergast, "In any event, it seems much lower than 50 ohms, at least up to heights approaching 0.2 wavelength, and that's over 50 feet."

"That's right," I said. "And the simplest solution to this little problem is to place a matching coil at the center of the dipole, right across the feed point. All that needs to be done is to adjust the turns in the coil for the lowest value of s.w.r. on the transmission line. This is a simple form of L-network, as I discussed in the June *CQ* antenna column. My discussion applied only to the compact, loaded dipole, but the impedance matching scheme applies equally well to the full-size dipole, as its input impedance is still quite low, because of its low height, in terms of wavelengths."

"The solution is very simple. Place an impedance matching coil across the center of the dipole and adjust the number of turns in the

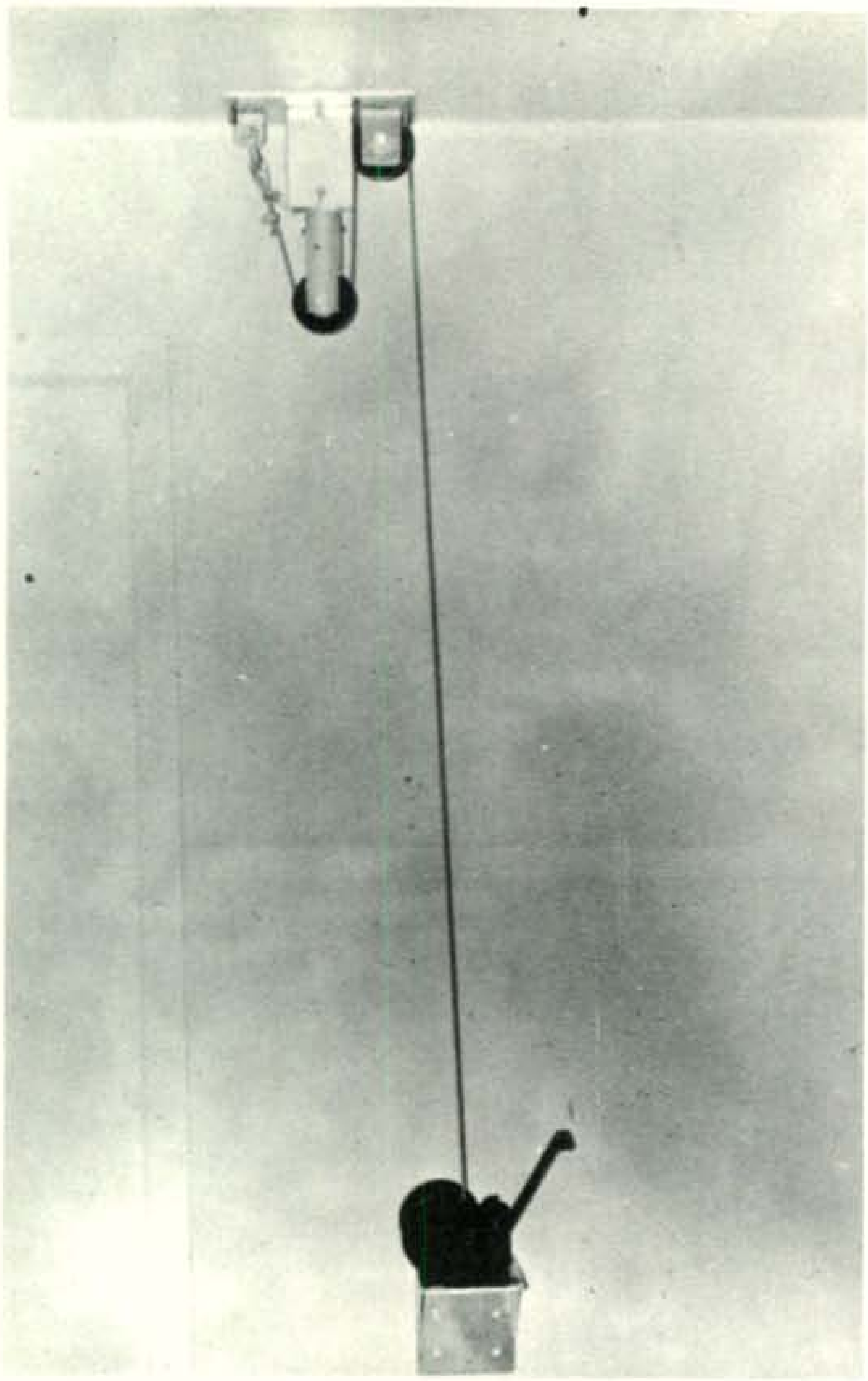


Fig. 7—The WA3HDU mast fully extended. The wall-mounted hoist has taken in the cable, pulling the telescoping mast to full height. The antenna is all ready to work DX!

coil for the lowest s.w.r. at the resonant frequency of the antenna. The impedance range you are interested in lies between approximately 30 ohms and 10 ohms. Above 30 ohms, the coil really isn't necessary. To achieve a good match to a 50 ohm line, the coil inductance should be as shown in fig. 3. If you don't know the input impedance of the antenna, you can start with the full coil in the circuit and gradually reduce it a turn at a time until you get a good match. A 3 microhenry coil is about right. A coil composed of 17 turns of #14 wire, one inch in diameter and two inches long will do the job. Wind it on a short length of plastic PVC pipe. The coil, in fact, will serve as the center insulator for the antenna. With a jumper, short out a turn at a time until you achieve a satisfactory value of s.w.r. at the resonant frequency of the antenna. For most antennas, you'll end up with about 8 or 9 turns in the circuit."

"Simple enough," said Pendergast. "I suppose the idea works whether or not you use a balun at the center of the dipole?"

"Correct," I replied. "I usually use a balun, but many fellows do not. It is strictly a matter of preference, I think."

Pendergast paused and looked over at the operating desk as I replaced the bound volume of *QST* in the bookcase. "Any interesting mail?" he asked.

"Yes," I admitted. "I received an especially interesting letter from Fred Hock, WA3HDU. Fred lives in a planned community where radio antennas are disallowed." He designed a disappearing antenna installation that received the approval of the Architectural Committee and he was kind enough to send me the information on it."

"Most Architectural Committees have a heart as cold as a Well Digger's boot," interrupted Pendergast." Its not easy to get approval of a ham antenna through those boys."

"WA3HDU did it with a disappearing tower. Look at the pictures (figures 4 through 7). Here's what Fred says: 'After working with antennas in the attic and fighting the detuning effects of air ducts and house wiring, I got the idea of a periscoping beam antenna. The antenna itself is a HY-Gain TH3, Jr., the smallest beam I could find. The main mast is 2-inch diameter aluminum tubing and vertical travel is about 7 feet. Along with a winch and cable, there are two bushings, one in the ceiling of the garage and the other in the roof. There is an anti-rotation pin for the mast built-in in both the extended and also in the fully retracted position. When erected, the antenna can rotate 360 degrees and has withstood winds up to 40 miles per hour.

'The crank-up beam was finally approved after 5 years (!) by the Architectural Committee. To the best of my knowledge, it is the first such approval here in Columbia, Maryland, which has a population of about 30,000 people, of which there are about 20 amateurs.

'I hope my experience in this precedence case might help others in some way and would be pleased to answer any questions on the subject.'

"Great!" exclaimed Pendergast. "It is a pleasure to see that an amateur met the antenna problem head-on and achieved a solution that was satisfactory to the City Fathers and to himself. Here's wishing plenty of DX for WA3-HDU and his telescoping antenna!"

73, Bill, W6SAI

antennas

BY WILLIAM I. ORR,* W6SAI

THE scratchy voice floated dreamily out of the still night air, an etherial whisper from long ago. It seemed far away and spoke of times past . . .

"The WNEW Dance Parade carries on! Now, from *Frank Dailey's Meadowbrook,* on the Newark-Pompton Turnpike at Cedar Grove, New Jersey, we bring you the music of Larry Clinton and his orchestra with Bea Wain doing the vocals. For their first number . . . "

I walked to the door of the shack and gently opened it. In the dusk I saw the shadow of Pendergast, sitting in his vintage 1939 Ford V-8 roadster in the driveway, listening intently to the car radio.

"Good evening," I said. "I can see how you've recreated the car and the radio, but how did you recreate the old radio program?"

"Easy," said my friend Pendergast. "I have a tape deck in the car. It's easy to get tapes of old radio programs. How would you like to listen to the *Tasty-Yeast Jesters, Uncle Henry's Showboat,* or *Fred Allen's Town Hall Tonight?"*

"No, thanks," I replied. "Nostalgia just isn't what it used to be."

"I'll save a tape of Jean Goldkette's orchestra for you," said Pendergast, snapping off the tape deck, vaulting over the car door, and advancing towards the radio shack. "Since you refuse the past, let's talk about the present. What's doing

*48 Campbell Lane, Menlo Park, CA 94025.

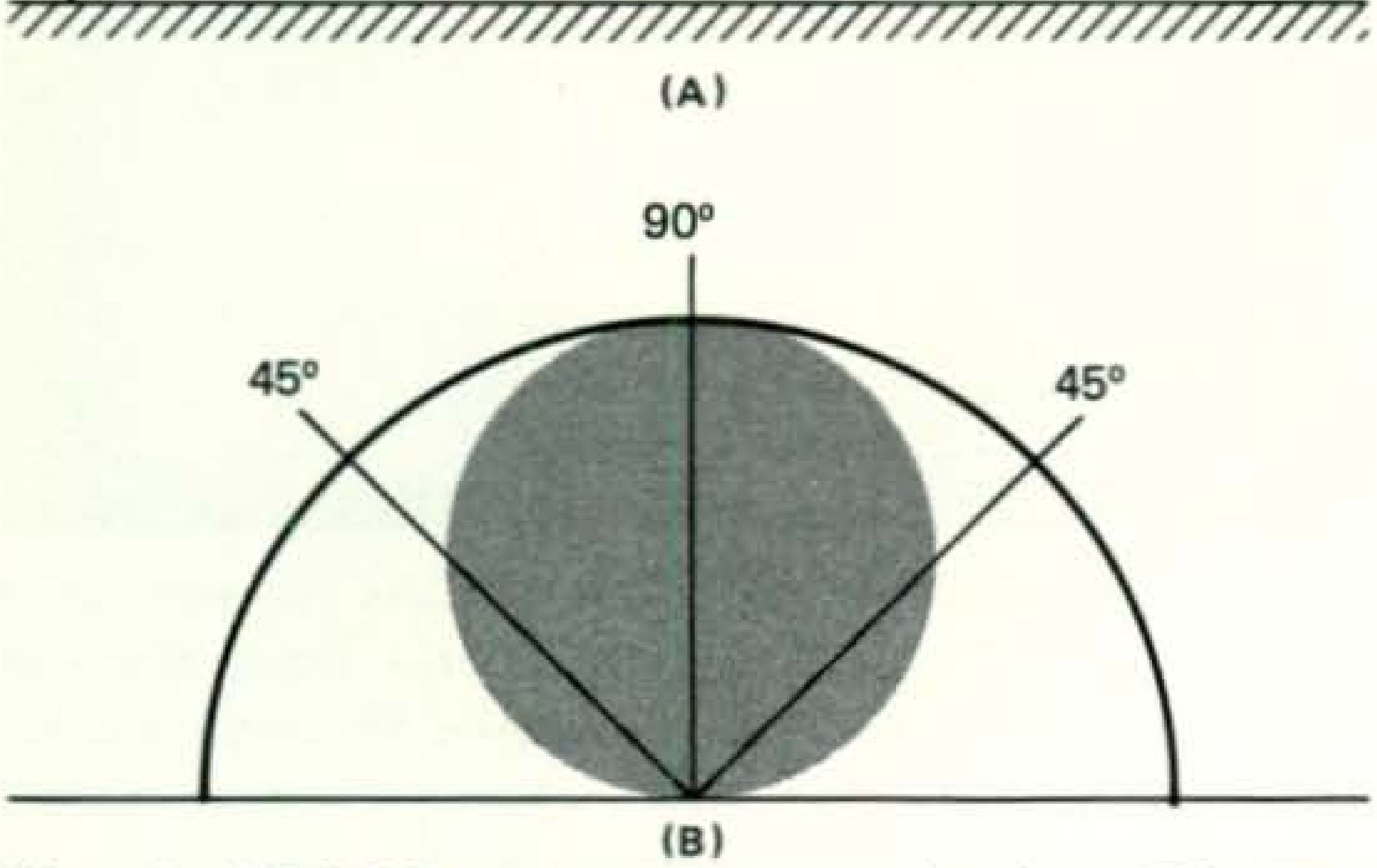


Fig. 1—G3AQC pattern test results for 470 MHz Inverted V.

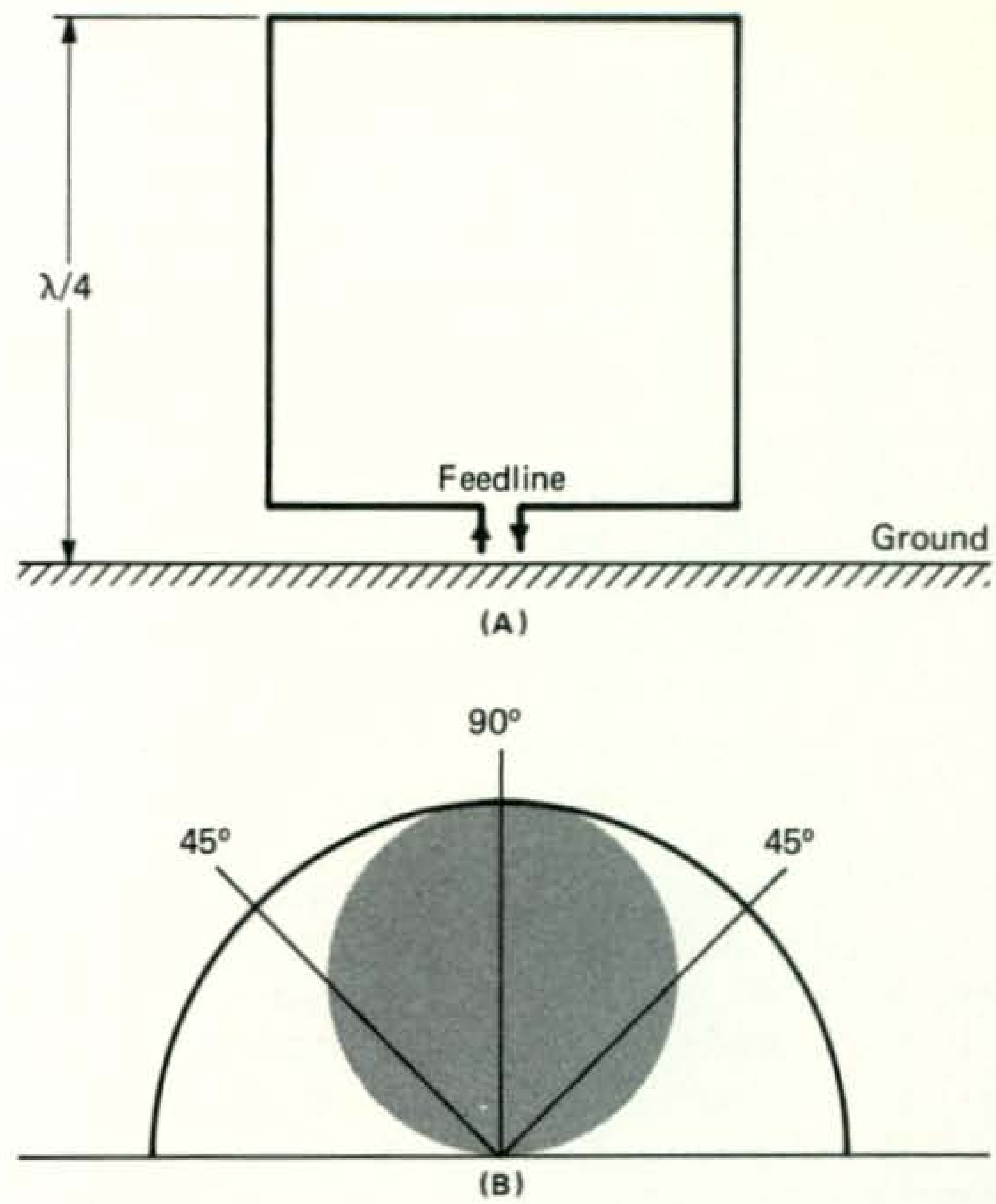


Fig. 2—Pattern test for horizontally polarized 470 MHz Quad loop.

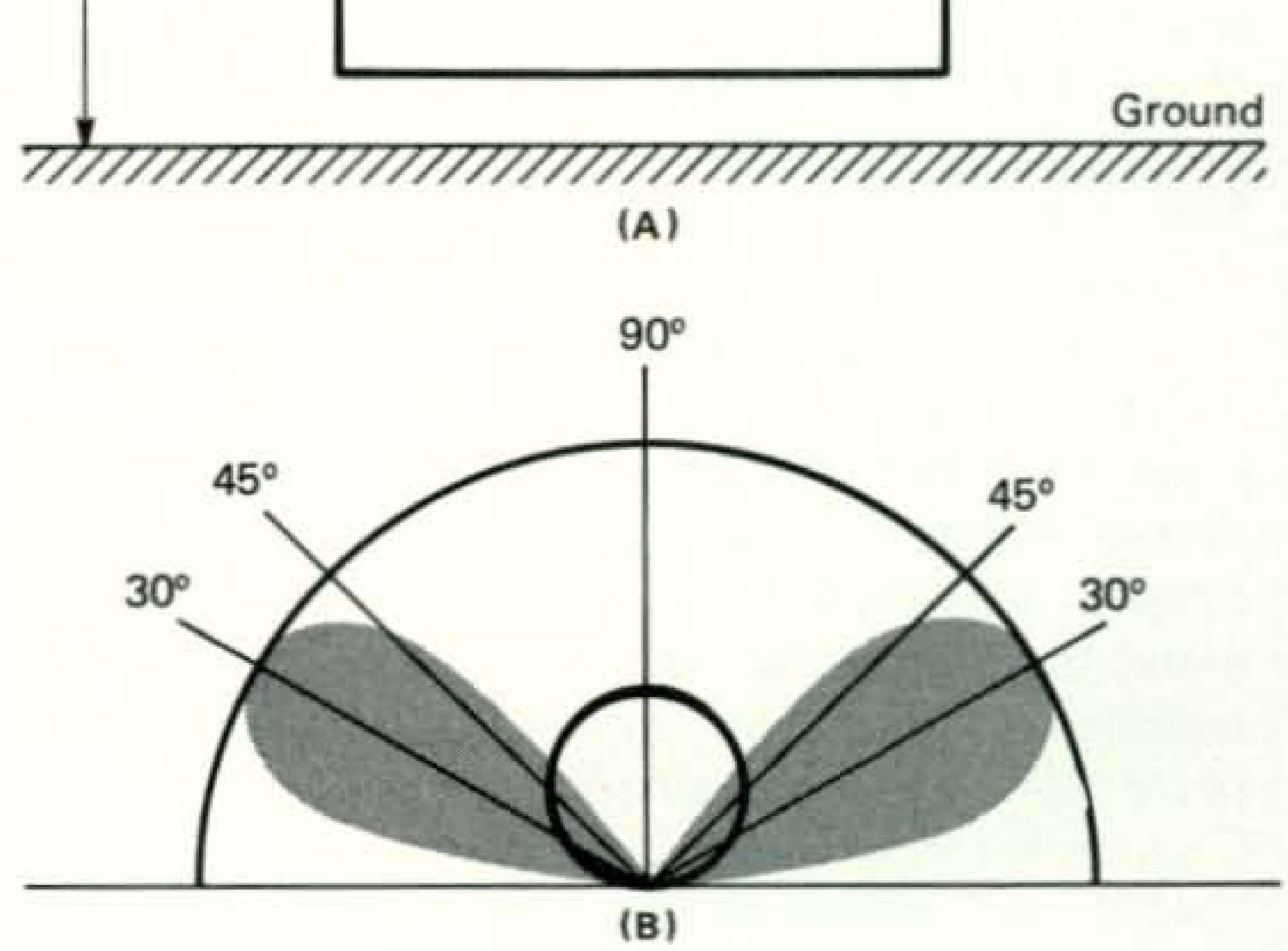


Fig. 3—Vertically polarized Quad loop pattern test.

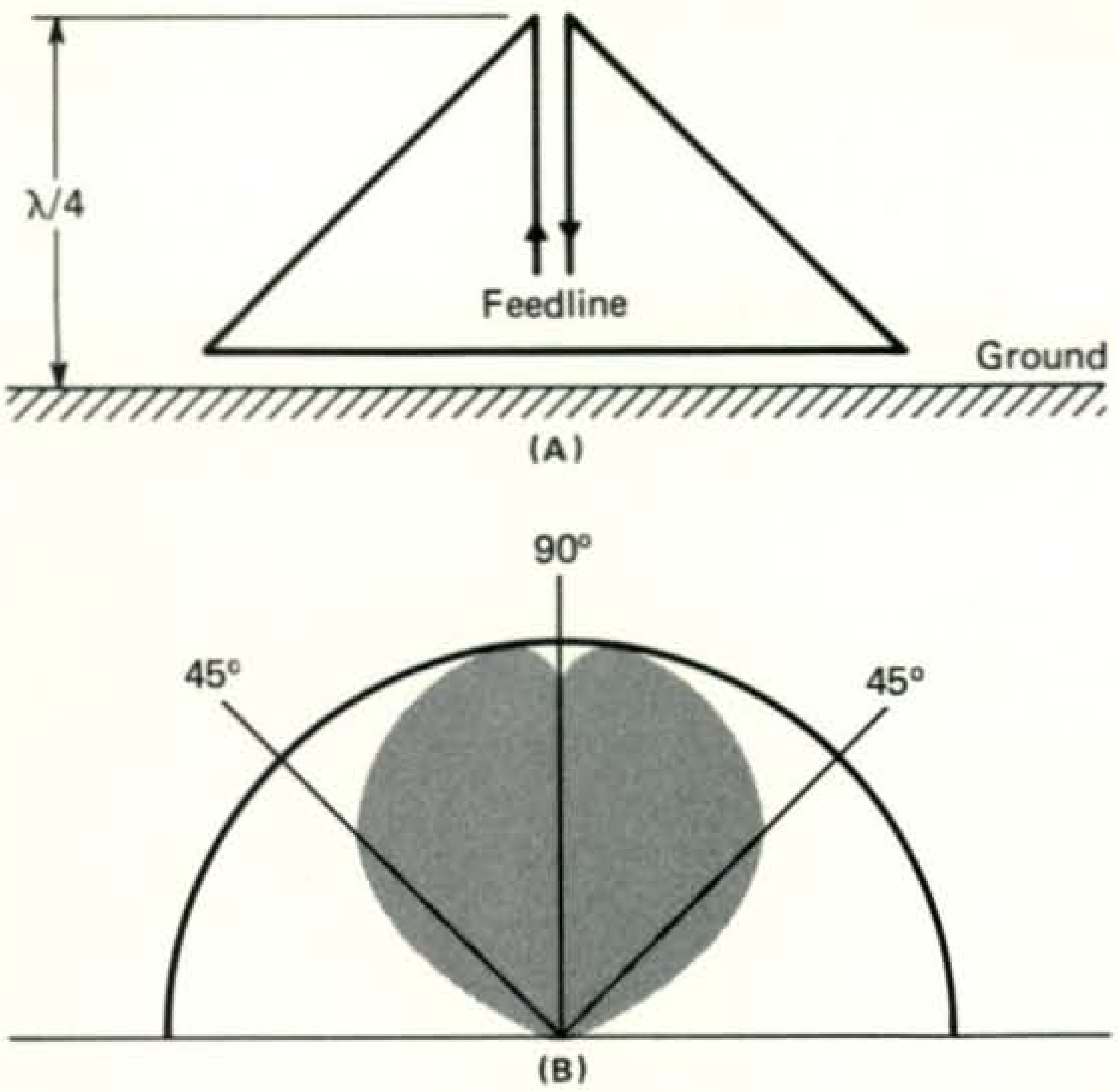


Fig. 4—Pattern test by G3AQC for 470 MHz Delta loop fed at the apex.

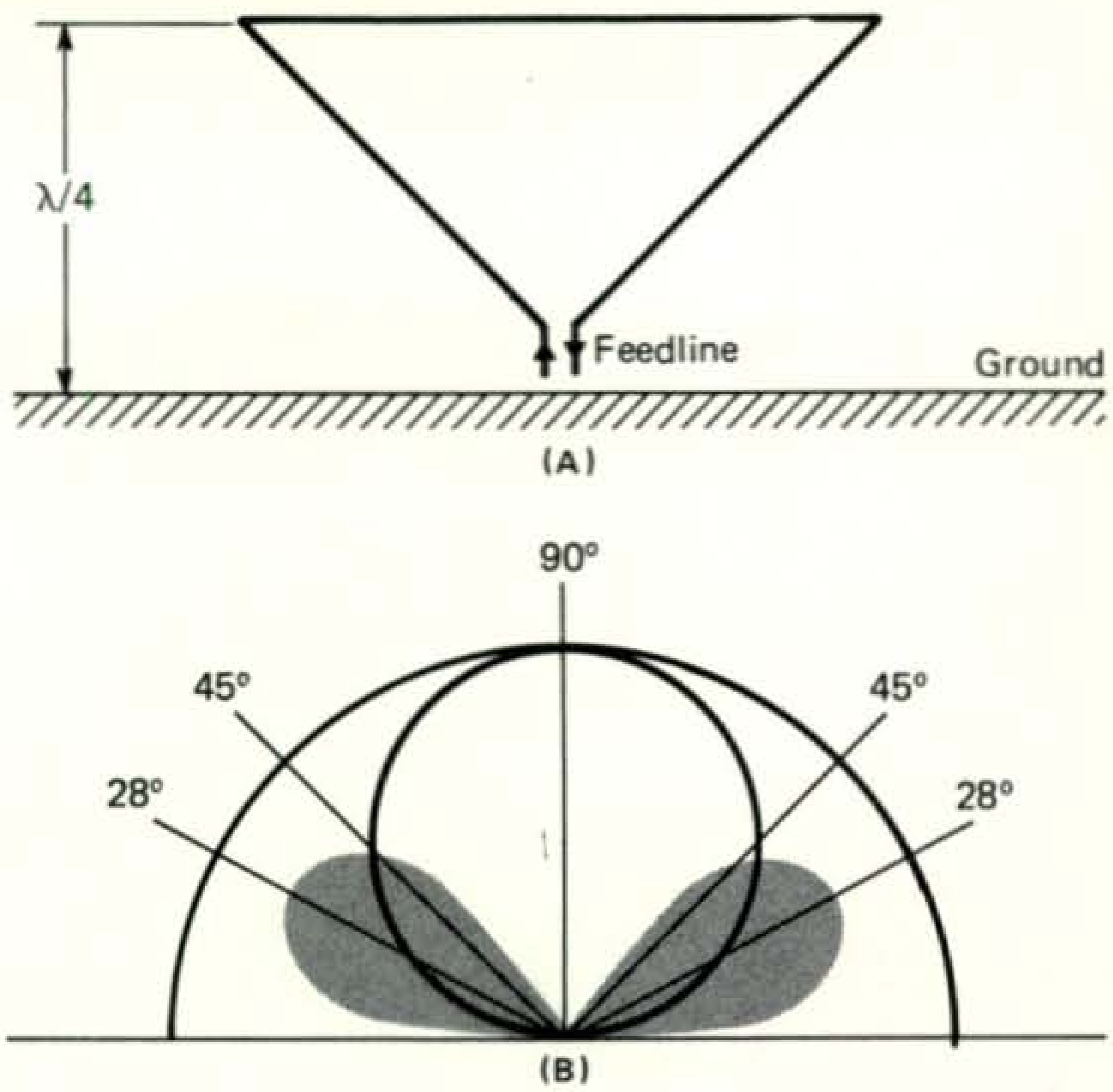


Fig. 5—Upside down Delta loop fed at the apex.

in the real-world of today, especially with regard to antennas? I'm particularly interested in antennas for 80 and 40 meters, now that the sunspot cycle is so low. What do you have new and interesting in this field?"

"Well, first of all, the Award-of-the-Month goes to our British friends in the Radio Society of Great Britain, with their fine magazine *Radio Communication*. In a recent issue, Laurie Mayhead, G3AQC, has a first-class article on the use of Quad and Delta loops placed very close to the ground."

"That's *great!*", exclaimed Pendergast." The big problem on 80 meters is to get a good DX antenna with a low angle of radiation. Since a quarter-wavelength is nearly 70 feet, this is almost an impossible situation. You just can't get the 80 meter antenna high enough in the air for best results. And I don't particularly like the noise pickup of a vertical antenna."

"It's a tough situation," I agreed. "However, G3AQC's tests point out that it is possible to get a reasonably good, low angle signal for 80 meter work with a low Quad, or Delta loop. He conducted a series of experiments at 470 MHz using resonant loops mounted close above a ground plane and plotted the vertical and horizontal field patterns at a distance of five wavelengths. The story is in the May, 1974 issue of *Radio Communications*. His data opens up a whole new insight into the performance of loops at low elevations. It is great information for the 80 meter DX operator.

"G3AQC checked his range by plotting patterns of a vertical quarter-wave antenna and also a dipole placed ¼-wavelength above ground. He got the usual radiation patterns you see in all the Handbooks. The vertical whip had a pattern hugging the ground and the dipole's pattern was at 90 degrees to the earth's surface . . . in other words, straight up!

"His next test was with an inverted-V dipole with the apex ¼-wavelength high. The included angle of the V was 90 degrees. The radiation pattern resembled that of the horizontal dipole (fig. 1)."

"Ha! That says the inverted-V, close to the ground, is no better than a dipole. That will make a lot of enthusiastic users of the inverted-V unhappy," said Pendergast with a sly grin.

"The next series of tests were run with a loop antenna," I continued. "Look at fig. 2. This is a horizontally polarized Quad loop fed at the base, with the top just over ¼-wavelength in the air. Again, most of the radiation is at 90 degrees with respect to the ground plane. Not a very good antenna for DX. But notice the

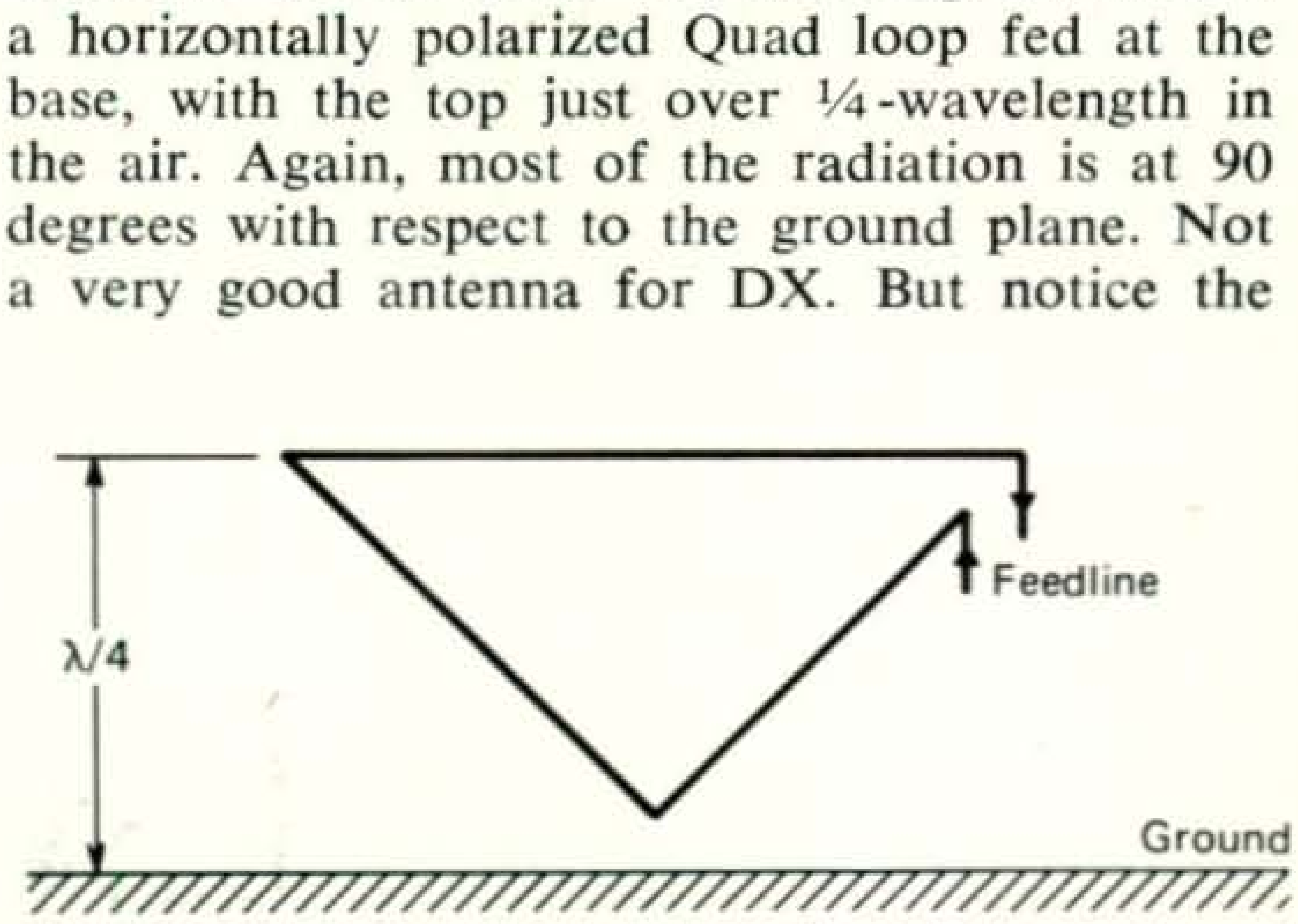


Fig. 6—Pattern test of 470 MHz inverted Delta loop fed at corner.

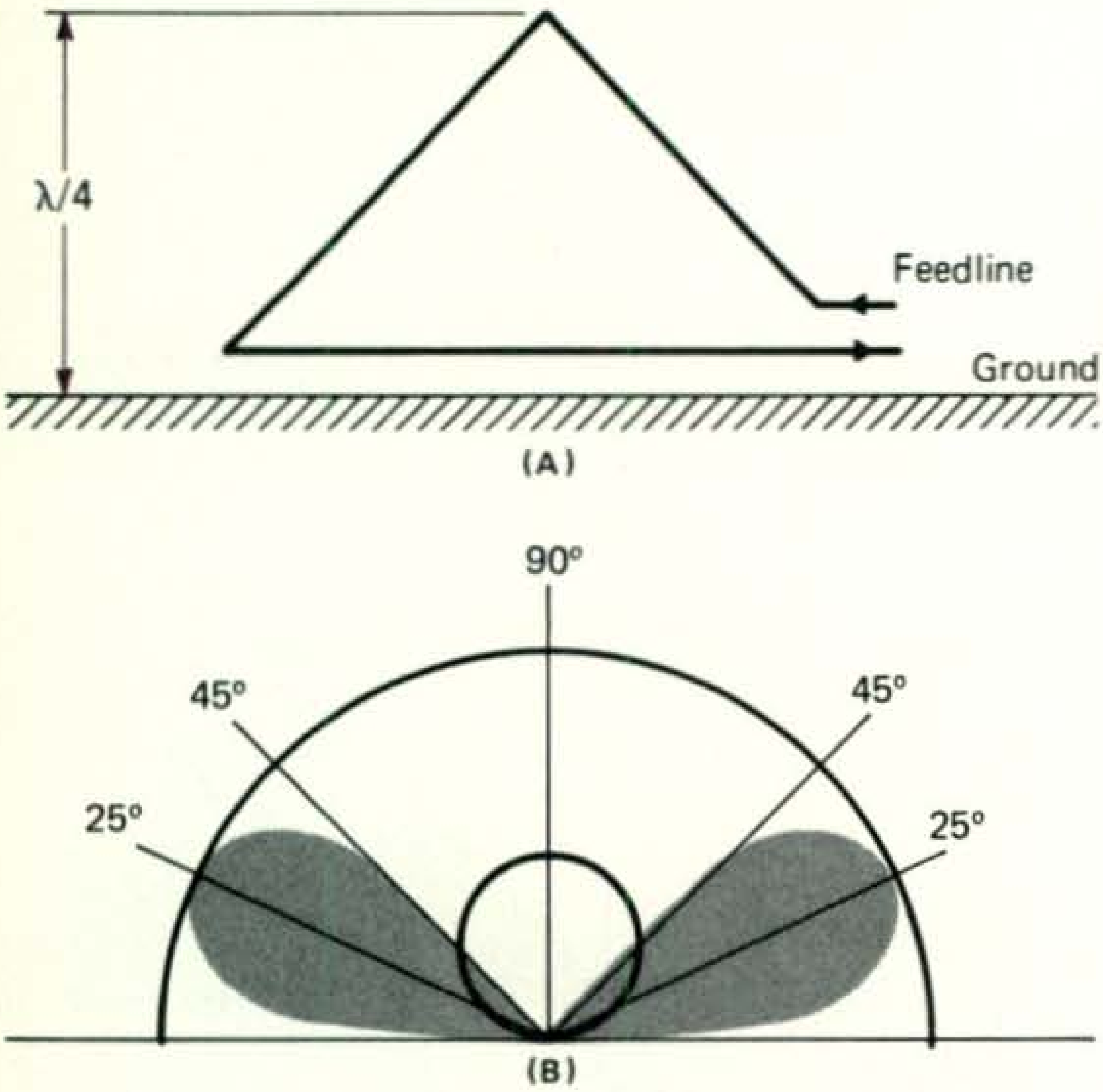


Fig. 7—Right side up Delta loop fed at corner.

improvement when the loop is fed with vertical polarization (fig. 3). The main lobe is at 30 degrees, with an extra high-angle horizontally polarized lobe of radiation."

"That's not a bad antenna pattern for a Quad loop so close to the ground," remarked my friend. "I would guess that it would have less ground loss than a ground-mounted vertical antenna, unless the vertical had a lot of radials under it."

I continued. "G3AQC's next experiment was with a Delta loop fed at the apex (fig. 4). Not so good: all high angle radiation again. So he inverted the loop, placing the apex at the bottom (fig. 5). He now found the usual high angle horizontal lobes, but also very useful lobes of vertically polarized energy at an angle of about 30 degrees above the horizon. His next step was to take the Delta loop of fig. 4 and feed it at the center of the horizontal section. Again, the results were only fair: mostly high angle radiation."

Pendergast studied the drawings. "Well, it looks to me as if the inverted Delta loop may have something going for it," he remarked.

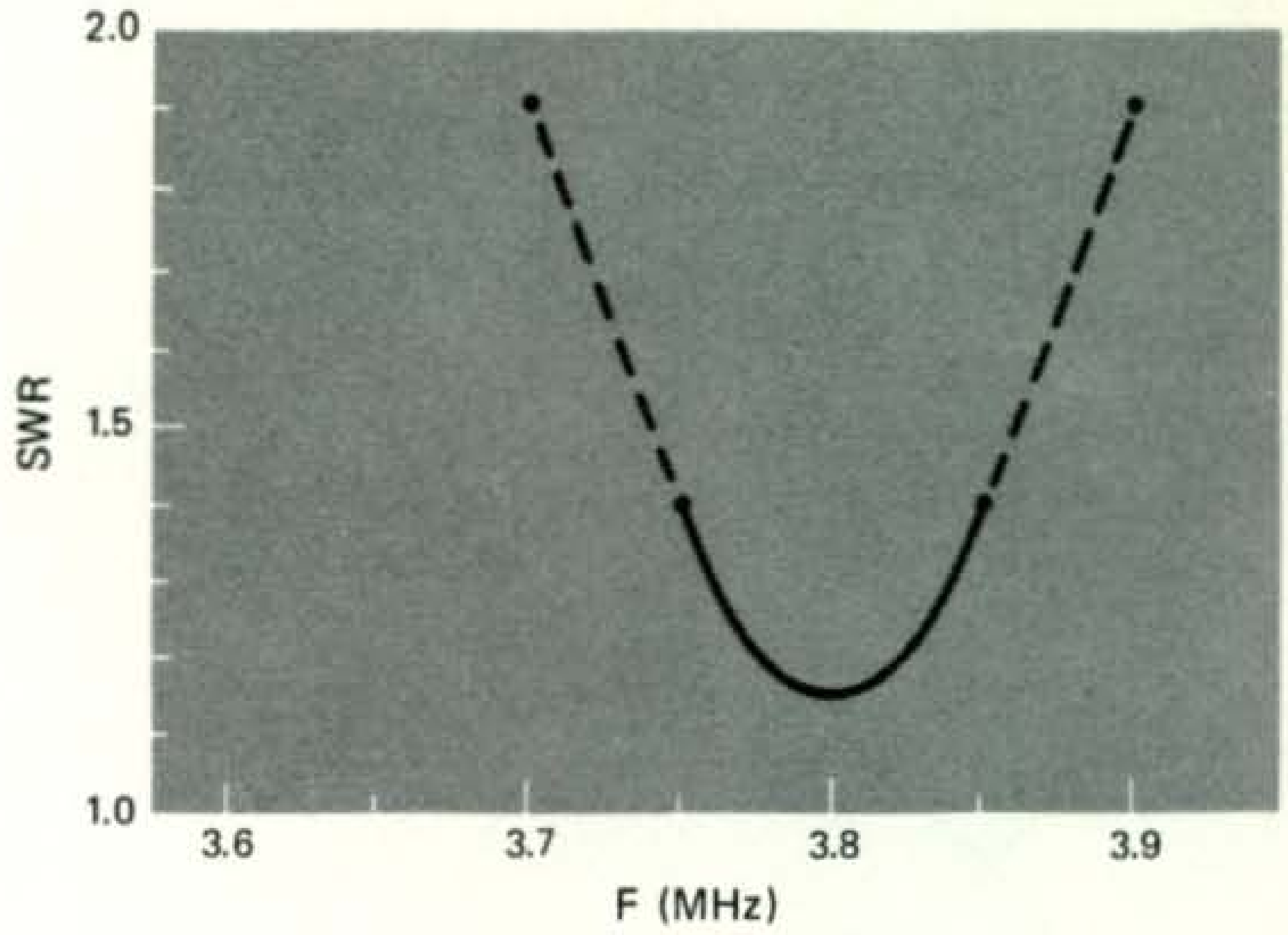


Fig. 8—S.w.r. curve for actual size 80 meter inverted Delta loop fashioned after the 470 MHz model of fig. 6.

"Did G3AQC run any more tests on this design?"

"Yes, he did," I said. "The next test was to feed the inverted Delta loop at one corner (fig. 6). This provided a large, vertically polarized lobe of radiation at about 20 degrees above the horizon, plus a small amount of high angle, horizontally polarized radiation. While these tests were being conducted, G3ZTH reported good results with a similar design (fig. 7), which was a Delta loop fed at a bottom corner. This provided a similar pattern to the inverted loop, but required only a single pole for support."

"That sounds interesting for the 80 meter DX hound," said Pendergast. "Did the G's ever try full-size antennas of this type on the lower bands?"

"Well, they built two antennas for 80 meter operation," I replied. "The first one was the design of fig. 6. The actual s.w.r. curve for 80 meter operation is shown in fig. 8. Design frequency is 3.8 MHz. Two 65-foot-high supports held the loop in the air. A one-to-one balun was used at the feedpoint. This was necessary to prevent radiation from the feedline. G3AQC used 75 ohm coaxial line in his design, but

[*continued on page 71*]

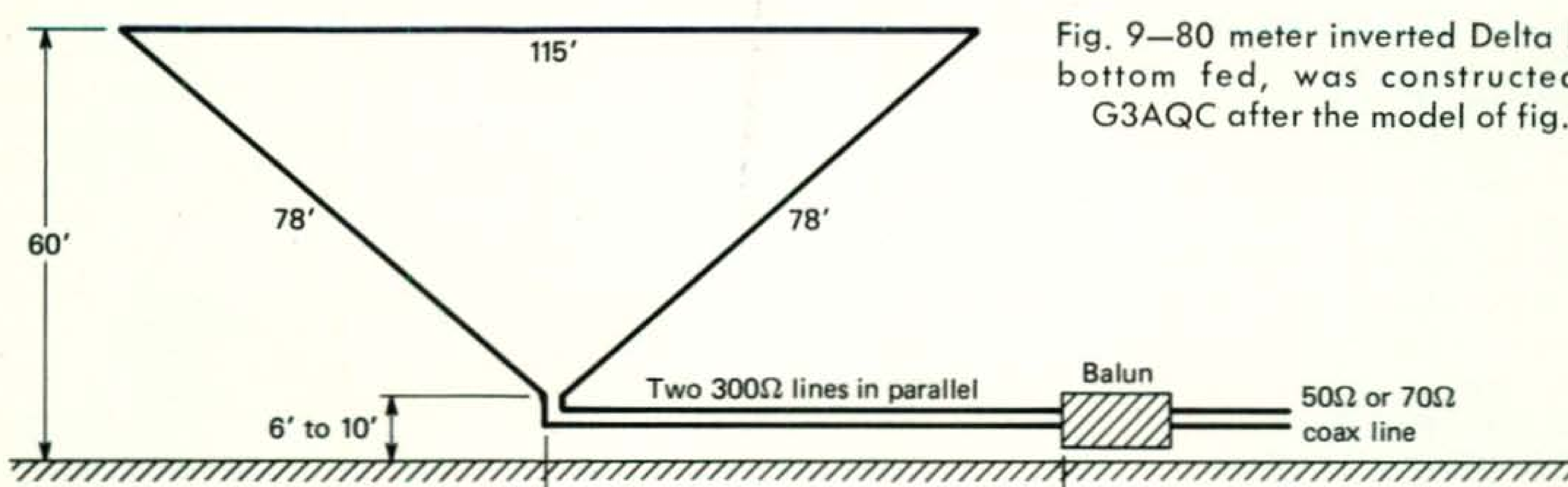
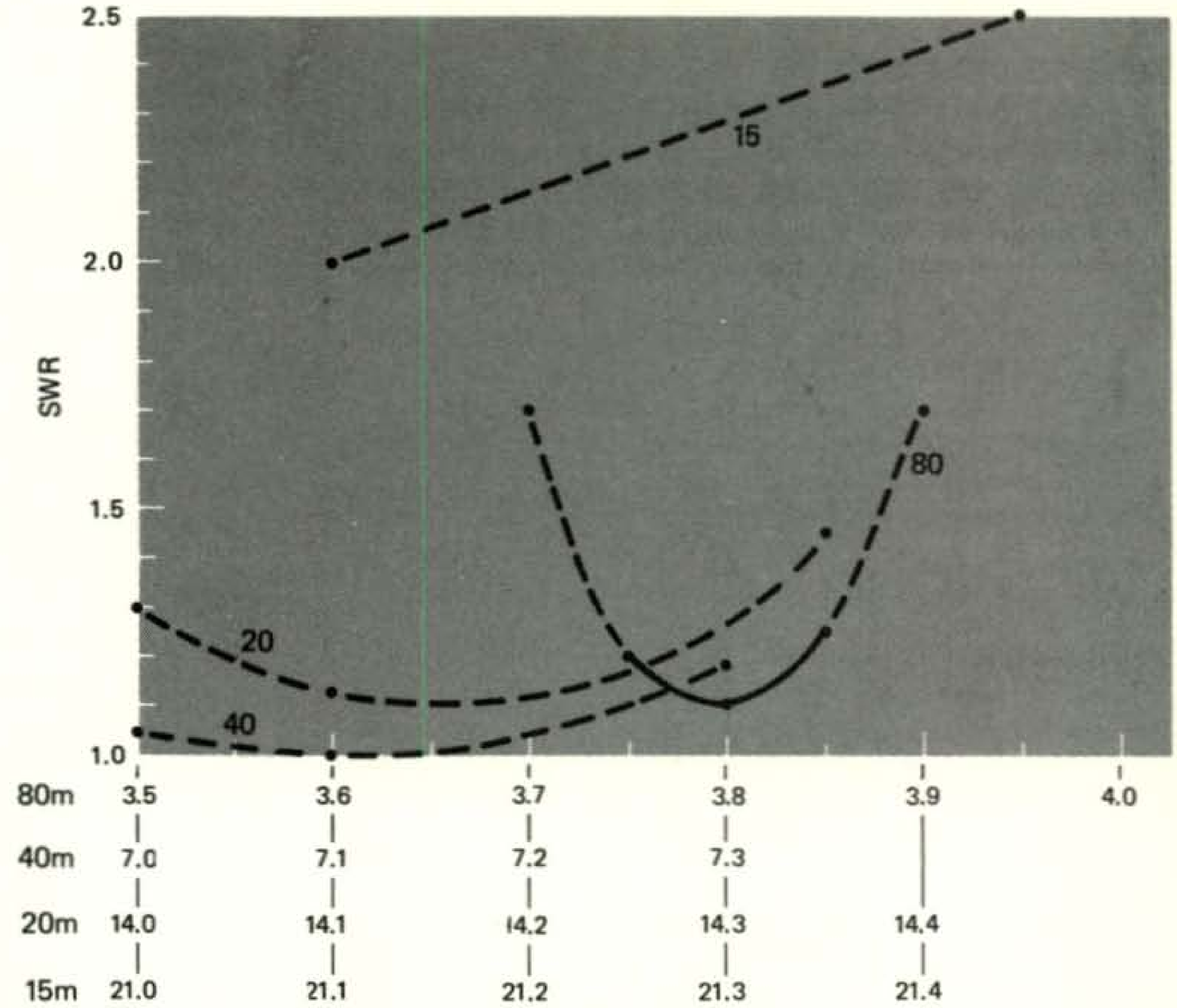


Fig. 9—80 meter inverted Delta loop, bottom fed, was constructed by G3AQC after the model of fig. 5.

Fig. 10—S.w.r. curves for the inverted Delta loop of fig. 9 when used on 80, 40, 20 and 15 meters.



Antennas[*from page 38*]

there's no reason why 50 ohm line can't be used. The radiation resistance of the loop is about 60 ohms so that provides a nice match to either 50 or 75 ohm lines. Incidentally, notice the good bandwidth of this simple antenna."

"What was the second antenna they tried?" asked Pendergast, making drawings in his notebook.

"The second one was an 80 meter inverted delta loop, fed at the bottom with a 150 ohm matching section, balun and 75 ohm line (fig. 9). The radiation resistance of the loop seemed to run about 180 ohms, so G3AQC used a quarter-wave matching transformer made of two lengths of 300 ohm TV ribbon line connected in parallel. Interestingly enough, the loop provided good performance on the 40, 20 and 15 meter bands, as well as on 80 meters (fig. 10).

"Because of the combination of horizontal and vertical radiation, the various loops are practically nondirectional on the fundamental frequency, the maximum variation in front/side ratio being measured as 6 db for the horizontal component and 4 db for the vertical component."

Pendergast studied the drawings, then asked, "I would guess that all of these loop antennas are sensitive as to ground conductivity, are they not?"

"Yes," I replied," Especially in the case of the vertically polarized radiation. However G3AQC reports that the loop configuration provides 5 db to 10 db improvement on long-haul DX on 80 meters as compared to a center-fed dipole, even though his ground conductivity is quite poor".

"Well," said Pendergast, "I hope some of your *CQ* readers try these interesting antennas and report back on how well they perform. Getting a good DX antenna for 80 meter operation is no easy task!"

"That's right," I agreed. "Eighty meter DX is on the increase as the higher frequency bands poop out during the low portion of the sunspot cycle. Since very few amateurs have 80 meter rotary beams on 180 foot high towers, the DXers have to do with what they can rig up, and that usually means wire-type antennas located relatively close to the ground.

"Many 80 meter types favor vertical antennas. But that means an extensive radial ground system. And the vertical antenna is well-known for its noise pickup. It seems to me that some kind of loop is a good alternative, as it provides both horizontal and vertical polarization, it seems to be less dependent upon ground conductivity than does a conventional vertical antenna and it is cheap and easy to erect. Best of all, the loop type antenna is very forgiving: it radiates practically all of the r.f. that you are able to get into it."

Pendergast said, "Eighty meters is an idea band for antenna experimentation. You can build all sorts of wire antennas for a few dollars. They don't cost much, and if they don't work, you can take them down in minutes. And don't forget—a little antenna gain on 80 meters works wonders!"

,NOTE: For those *CQ* readers who would like to subscribe to *Radio Communications,* write to: Radio Society of Great Britain, 35 Doughty St., London WC1N, 2AE, England. In the U.S.A. contact: Communications Technology, Inc., Greenville, N.H. 03048). ■

antennas

BY WILLIAM I. ORR, *W6SAI

"You look as if you had lost your best friend," I remarked as Pendergast slowly walked in the door of the shack and settled into his favorite chair with a deep sigh.

"I aged 20 years in 20 minutes yesterday," he replied in a tired voice. "I never worked the *Mount Athos* gang. And boy! I really got shot out of the saddle by Don, K5DUT. That was a real lesson in humility."

"Well, do you know what Don's using for an antenna? They do *big* things down in Texas."

"No," replied Pendergast. "What's he got? A stacked, rotary rhombic?"

I reached into the drawer of the operating desk and pulled out a QSL card and photograph. "Here it is," I replied (fig. 1). "Don has a 6 element, tri-band Quad on a 50 foot boom. It is 80 feet in the air. And he runs an *Alpha-70* amplifier into it. No wonder he rubbed your nose in the dust."

"I suggest we talk about something else," said Pendergast as he gazed at the photograph. "Anything of interest from your readers, to change the subject?"

I pointed to a letter on the desk. "There's a lot of good work going on in regard to low-band DX antennas now that the sunspot cycle is approaching a minimum. Look at the simple 80 meter antenna that WA6WUI is using (fig. 2). This is a sloping V-antenna and Howard ties the top of it onto his tower and has done right well for 80 meter DX. Each leg of the antenna is 63′2″ long and the feed point, or apex, is only 47 feet high. The feedline is 50 ohm coaxial line (RG-58A/U). The antenna is cut for 3.8 MHz and the feedpoint impedance was made to match the line impedance by adjusting the spacing between the ends of the legs. Howard moved one leg back and forth until he got an s.w.r. reading of 1.1 at 3800 kHz. The measured s.w.r. was below 2 between 3700 kHz and 3900 kHz. He finally ended up with a spacing of 63′2″ between the ends, which were about 4 feet clear of the ground.

"The ends of the antenna are hot, don't forget that, so you have to make sure that the

*48 Campbell Lane, Menlo Park, CA 94025.

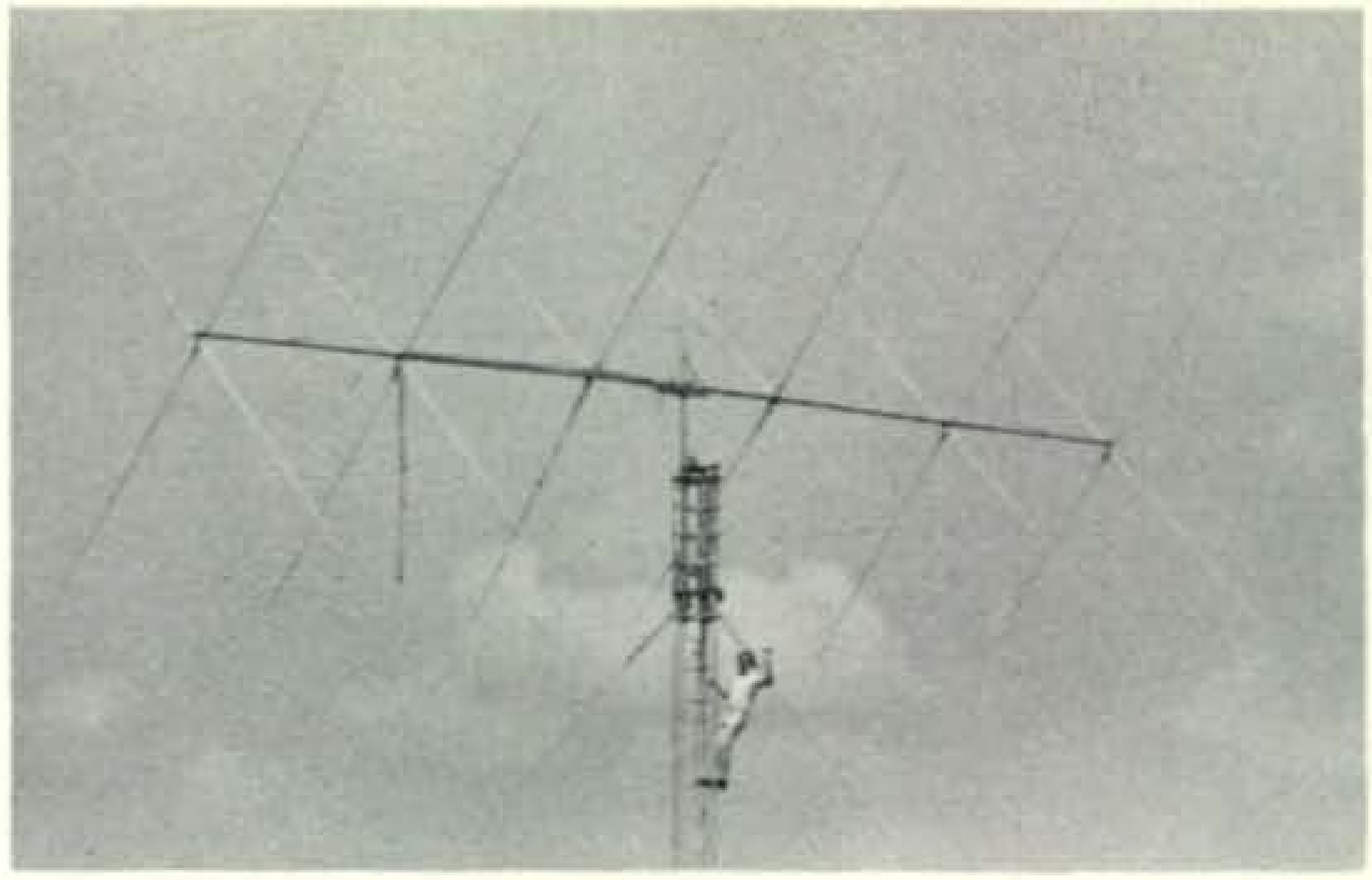


Fig. 1—The "big gun" at K5DUT. A six element Quad for 20, 15 and 10 meters on a 50 foot boom. The antenna is supported 80 feet in the air on a Rohn type 55 tower. Warning! Stay clear of Don in a pile-up.

neighborhood kids don't touch the wires when the rig is on the air. It might be a good idea to raise the ends so they can't be touched from the ground."

Pendergast was scribbling in his notebook, which he produced as if by magic from a pocket of his jacket. "How well does it work?" he asked.

"Howard says he's worked some interesting DX on SSB, such as VR1AA, 6W8DY, UP2A and VS6DO."

"Enough!" said my friend, holding up his hand in mock protest. "Anybody that can work that on 80 meter s.s.b. certainly has an antenna that works, no matter how simple it looks!"

"Well, I understand there's an even more simple 80 meter DX antenna called a *sloper,*" I replied. "I've never seen one, but I got a description of one from W6MZ. All it is is a quarter-wave wire, top fed and hung from a metal tower, like this." I drew fig. 3.

"That doesn't look right," objected Pendergast. "Where's the rest of the antenna?"

"That's all of it," I replied. "The shield of the coaxial line is grounded to the tower at the

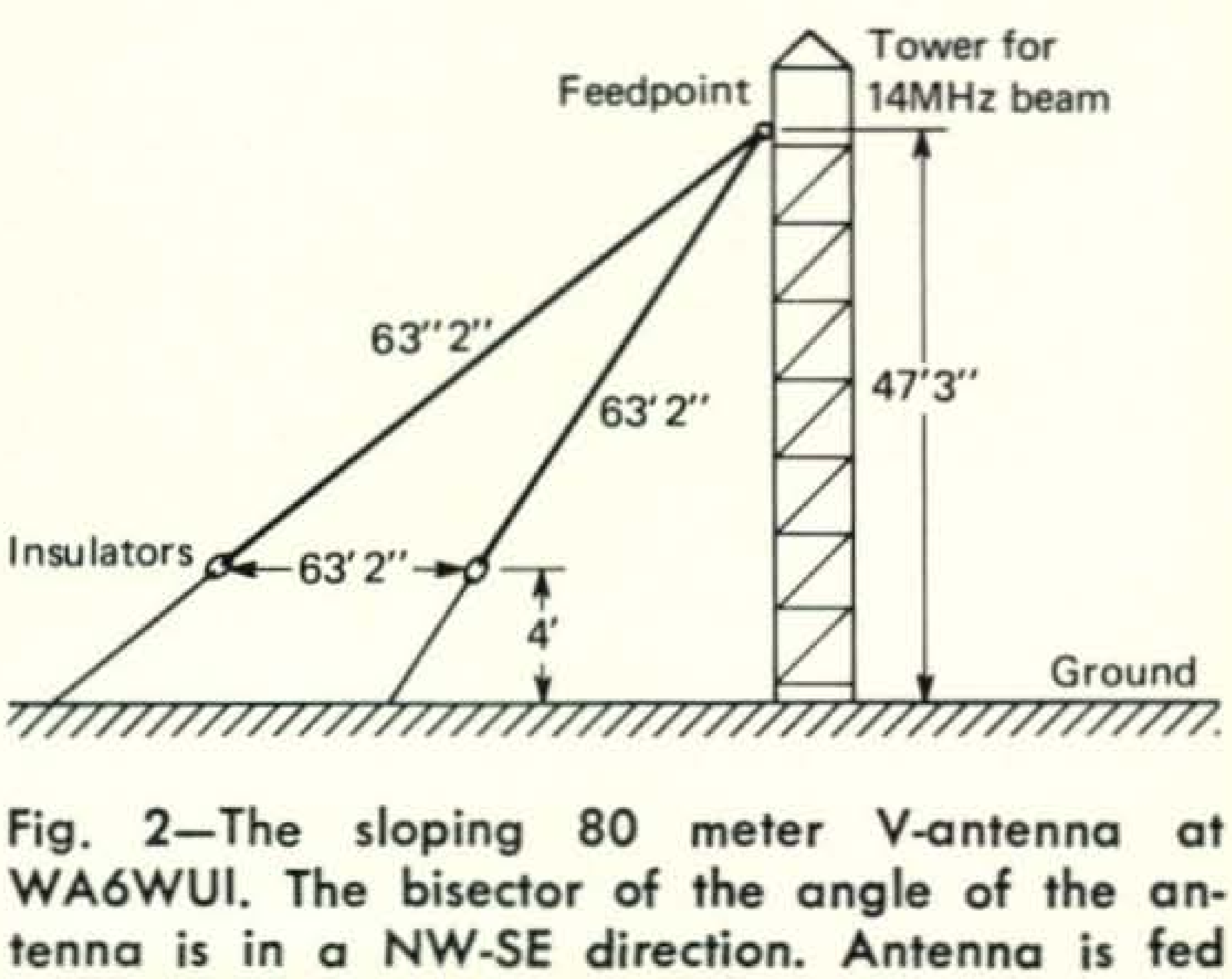


Fig. 2—The sloping 80 meter V-antenna at WA6WUI. The bisector of the angle of the antenna is in a NW-SE direction. Antenna is fed at the apex with 50 ohm coaxial line. Howard reports plenty of DX with this simple antenna.

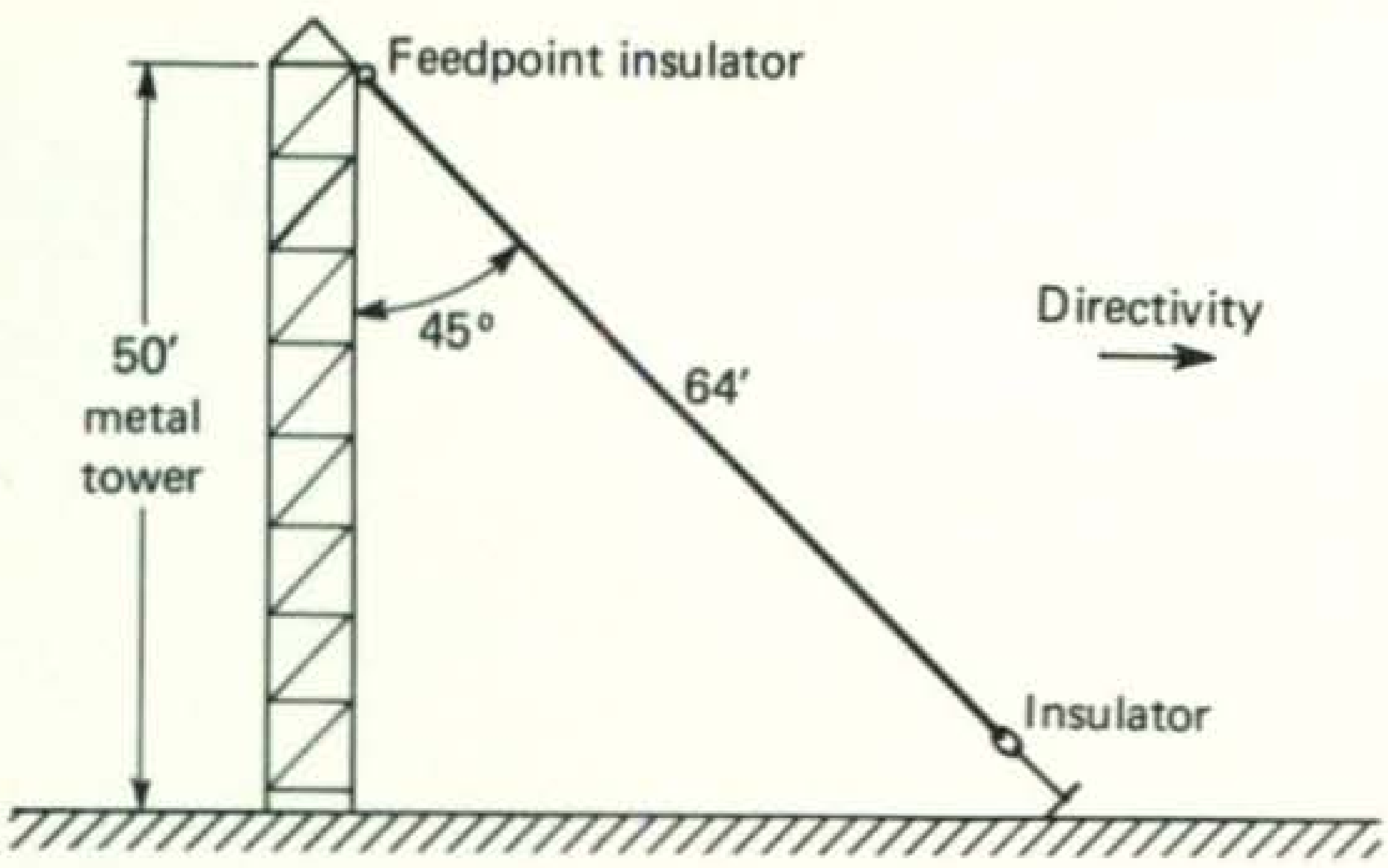


Fig. 3—The 80 meter "sloper" at W6MZ consists of a single wire, fed at the top with a 50 ohm coaxial line. The center conductor of the coax is attached to the wire and the braid is grounded to the tower. Jack suggests that if the tower is a sectionalized, crank-up affair, that it be shunted with a length of copper wire, as the electrical conductivity between sections is poor. When the wind blows, the SWR shifts slightly. The bottom of the tower is grounded by multiple rods driven into the soil.

top and the inner conductor is hooked to the antenna wire! I guess the tower acts as a sort of lop-sided ground plane. Who knows? But fellows seem to be using it. I would sure like to hear from somebody who has actual working knowledge of this screwey device. And look at the s.w.r. curve that Jack plotted for his sloper (fig. 4). That certainly is a broadband response. Beats me how it works, but it does."

"What else do you have up your kilties?" asked Pendergast.

"Here's another good one," I replied. "My old friend Carl, WØBWJ, works portable on occasion from an apartment in the San Francisco area. He's an airline pilot, you know, and always on the move. He's got an FT-101 transceiver in a carrying case and operates from all sorts of odd places with makeshift antennas. Well, he can't put up an antenna in

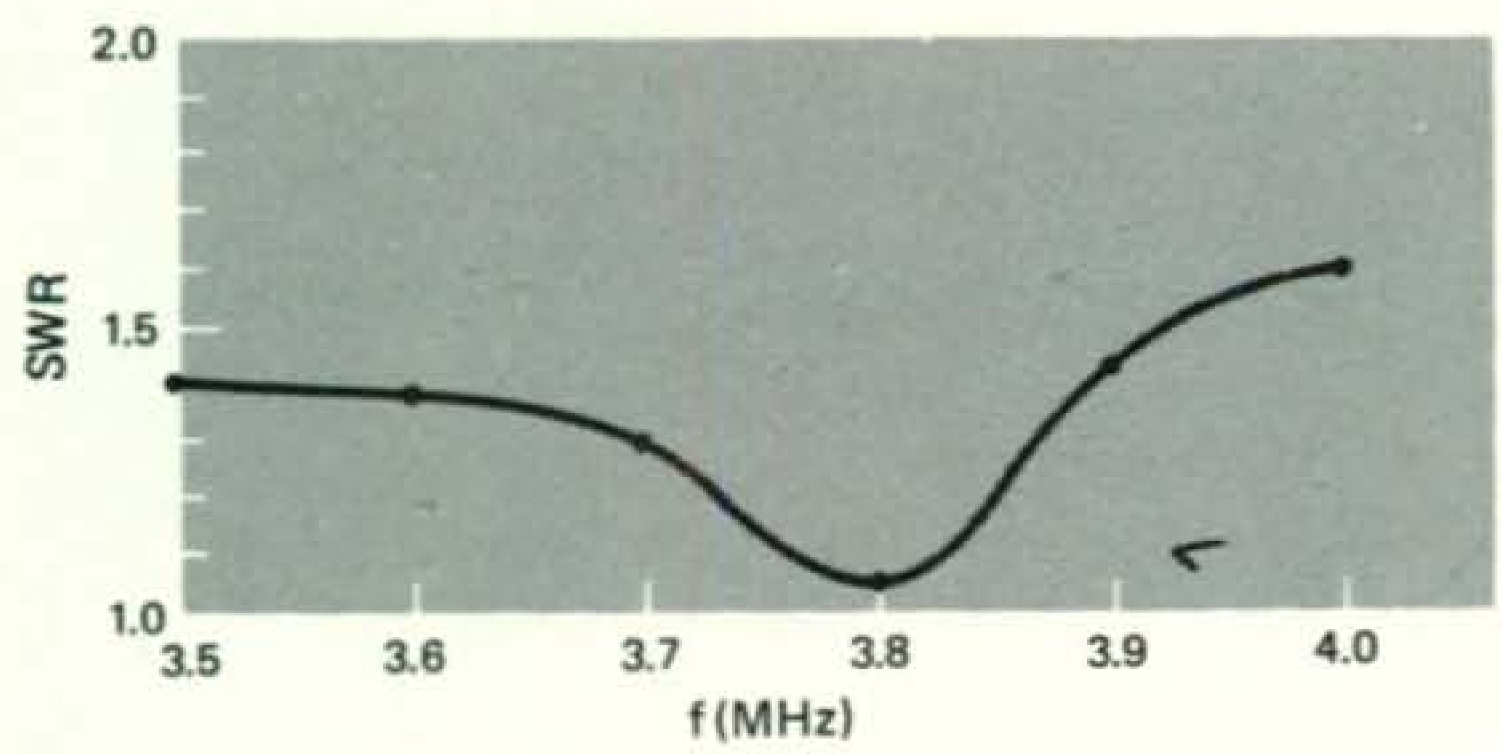


Fig. 4—The s.w.r. plot of W6MZ's 80 meter "sloper" antenna cut for 3.8 MHz. Looks too good to be true, doesn't it? The author of this column would appreciate reports from other amateurs using this remarkably simple antenna. How does it work for you?

the apartment, because of landlord objections. So Carl examined the building closely and found that it had a double roof for ventilation purposes and that a screened ventilator slot ran all around the building, just under the eaves. The slot was to let warm air out of the attic space between the ceiling and roof of the building. The perimeter of the building was about 400 feet, and this slot ran all the way around it.

"Upon closer examination, Carl found the screening was laid down in sections, about a foot wide and 20 feet long. The section overlapped on the ends and they were held together with heavy double-pronged roofing nails.

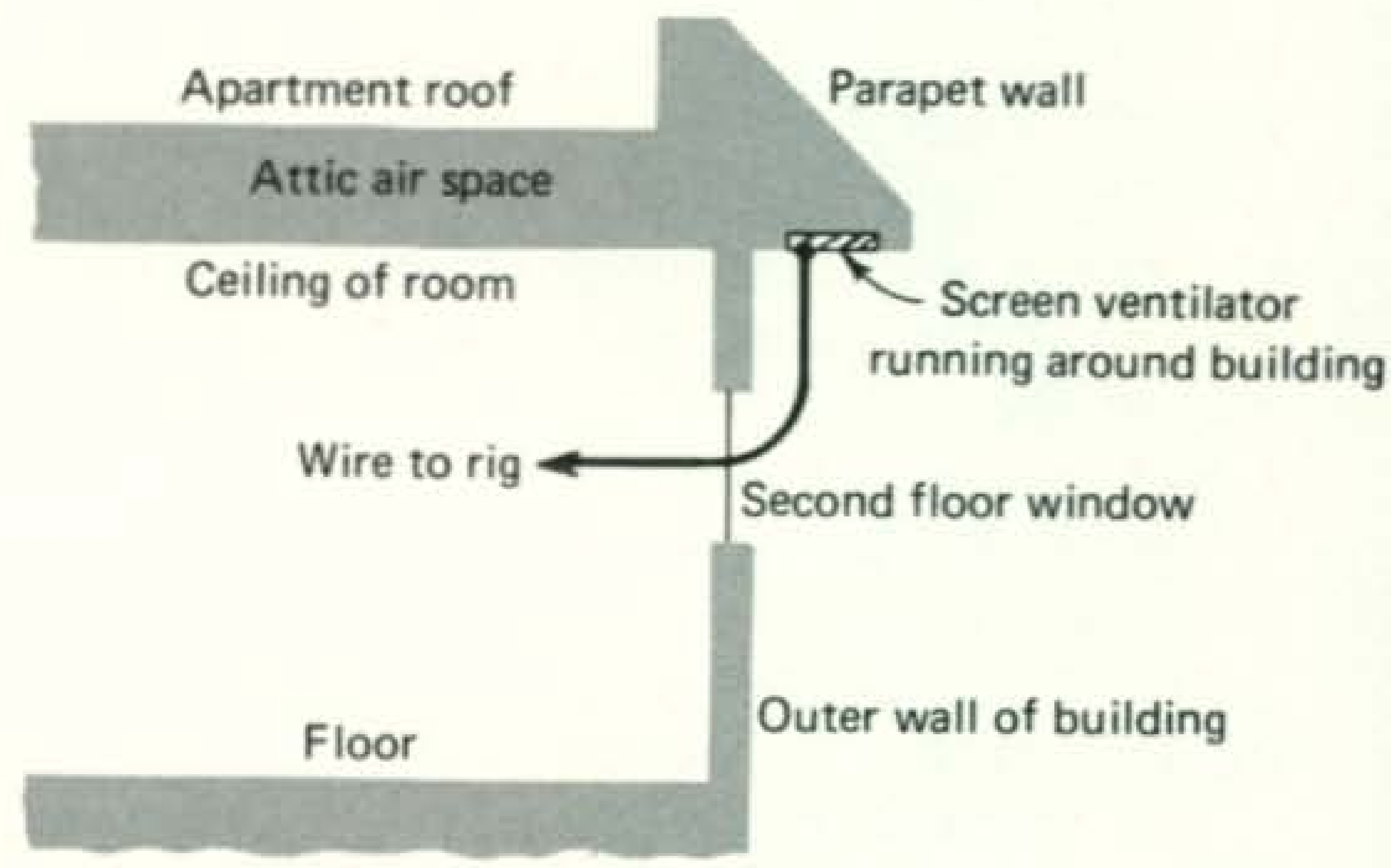


Fig. 5—The "invisible" antenna of W0BWJ/6. Carl uses the screened ventilating slot that runs around the base of the parapet wall of his apartment building as an end-fed antenna. He clips onto the screen and works it against a common ground composed of the water piping of the building plus individual ground radial wires. Perimeter of the building is about 400 feet, so there's plenty of radiating metal in the air.

"So he decided to make this screening his antenna! Look at fig. 5. He ran a short, insulated wire out the second story window with an alligator clip on the end. By merely reaching up, he clipped the screen just above his window. He used a utility antenna tuner such as in fig. 6. For a ground connection, he used the water system of the apartment, together with several quarter-wavelength ground radials, one of each band. The radials were made out of insulated hookup wire and ran across the floor, near the walls of the apartment. The 80 meter radial was 66 feet long, the 40 meter radial 33 feet long and the 20 meter radial 16 feet long. For 160 meters, he omitted the radial and just used the copper plumbing system.

"Carl reports that the makeshift antenna system works very well and he's maintained schedules with home and worked a lot of stations with the 'invisible' antenna. This just shows that you can't keep a good amateur off the air."

Pendergast said, "Too bad Carl can't get up on that flat roof. That would be an ideal location for an antenna".

"He'll just have to educate the landlord," I replied, "And that may take a lot of time".

Pendergast looked around the shack and his eye fell on the Japanese magazine *CQ Ham Radio*. "Anything interesting about antennas in that magazine?" he asked.

I hefted the May issue in one hand. "Look at that," I said. "You can't doubt that amateur radio is a success in Japan. This issue runs to 520 pages! Fantastic."

"What about antennas," demanded Pendergast, caught in a groove of his own choosing. "They usually have some pretty good information in that publication."

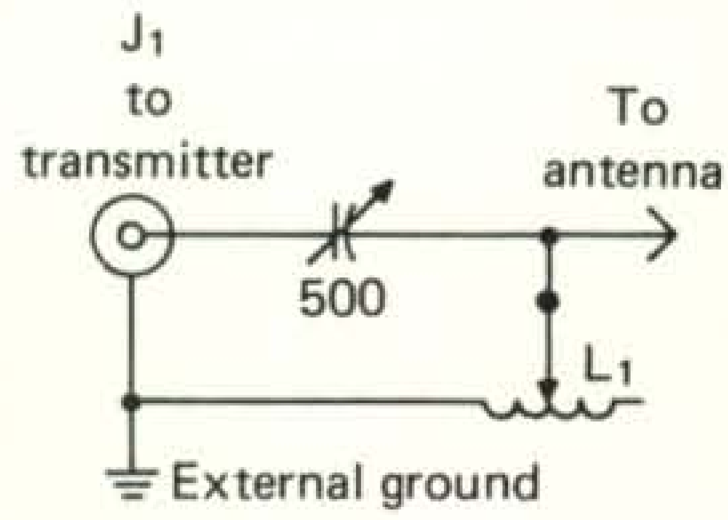


Fig. 6—The antenna tuner at W0BWJ/6. The capacitor is a double-spaced surplus unit, as is the coil. Tuning unit will match any random wire as long as it is not an exact multiple of quarter wave lengths. If a match cannot be achieved a 500 pf transmitting-type mica capacitor is inserted in the lead to the antenna.

"The center element, then, isn't used on 40 meters, is it?" asked Pendergast.

"Right," I replied. The 20 meter reflector acts as a 40 meter driven element, and the 20 meter director acts as a 40 meter director. In that way, optimum element spacing is maintained for the two bands.

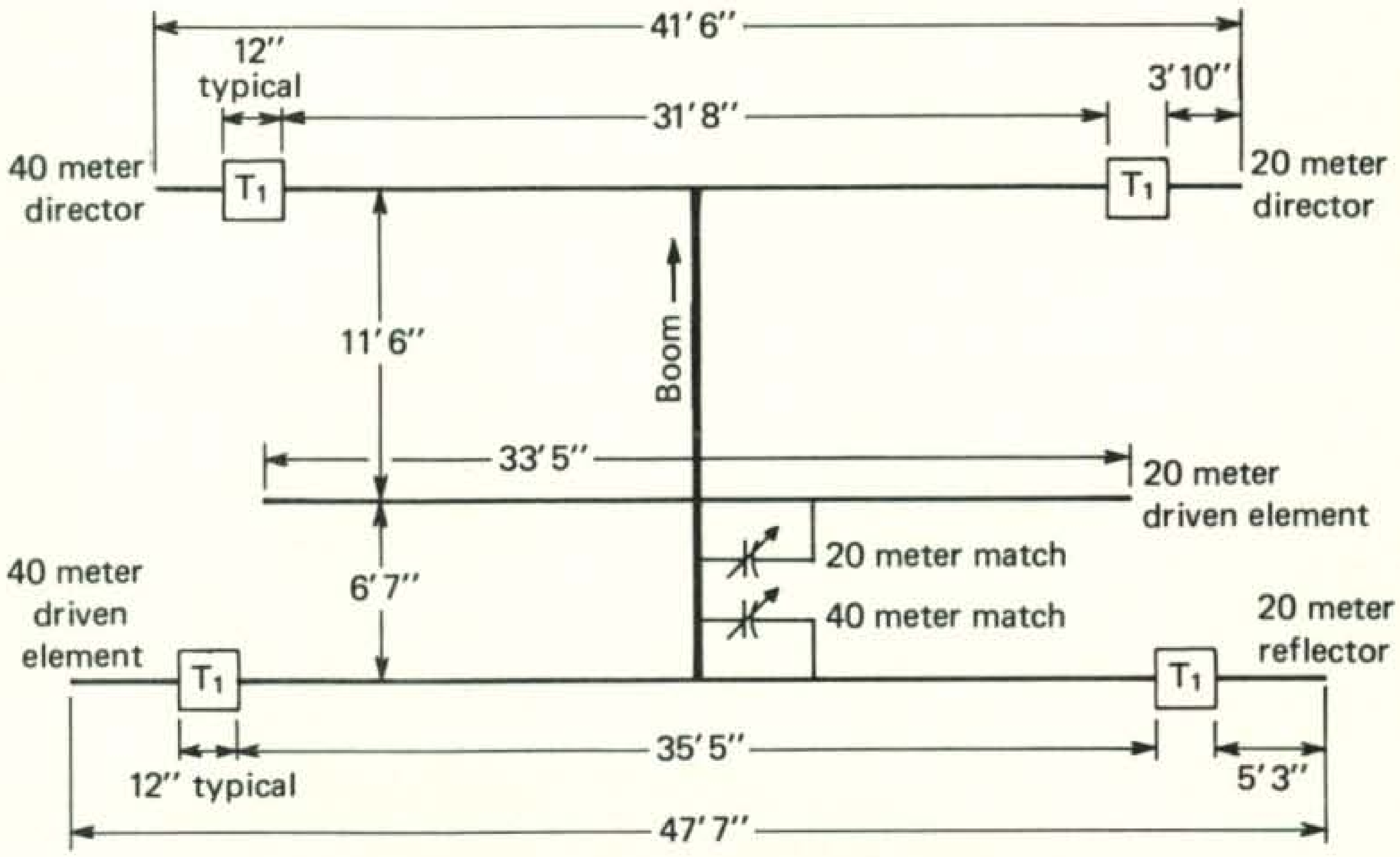


Fig. 7—Dimensions of 20-40 meter duo-band Yagi antenna at JA8JL and JA8AJS. Antenna is fed with a gama match for 40 meters and a modified omega match for 20 meters. See fig. 8 for matching systems. Beam diameter is 2½ inches. Elements are 1¼ inch at center, tapering to ⅞ inch diameter at the tips. Trap information is given in fig. 9.

"You are right," I admitted. "It is a pity I can't read Japanese. But a lot of the information is in English, and all of it is in the metric system. So, with a little guesswork, and a handy pocket calculator, it is possible to squeeze a lot of good information out of the articles."

Pendergast leafed through the magazine. "How about this discussion of a 20-40 meter trapped Yagi by JA8JL and JA8AJS?" he asked.

"That's a good one," I replied. "I've seen very little practical information in print on a two band parasitic array for 20 and 40 meters. This looks like one that will work. "Here's a sketch of the beam (fig. 7). Basically, it is a 3 element Yagi on 14 MHz and a 2 element Yagi on 7 MHz. Bandswitching is accomplished by the use of traps in the 20 meter director and reflector.

"On 20 meters all three elements are used. The center element is the radiator, and the outer elements are the reflector and the director. The antenna is fed with a gamma matching system. On 40 meters, the outer elements take the form of a director and a driven element and the center element is unused.

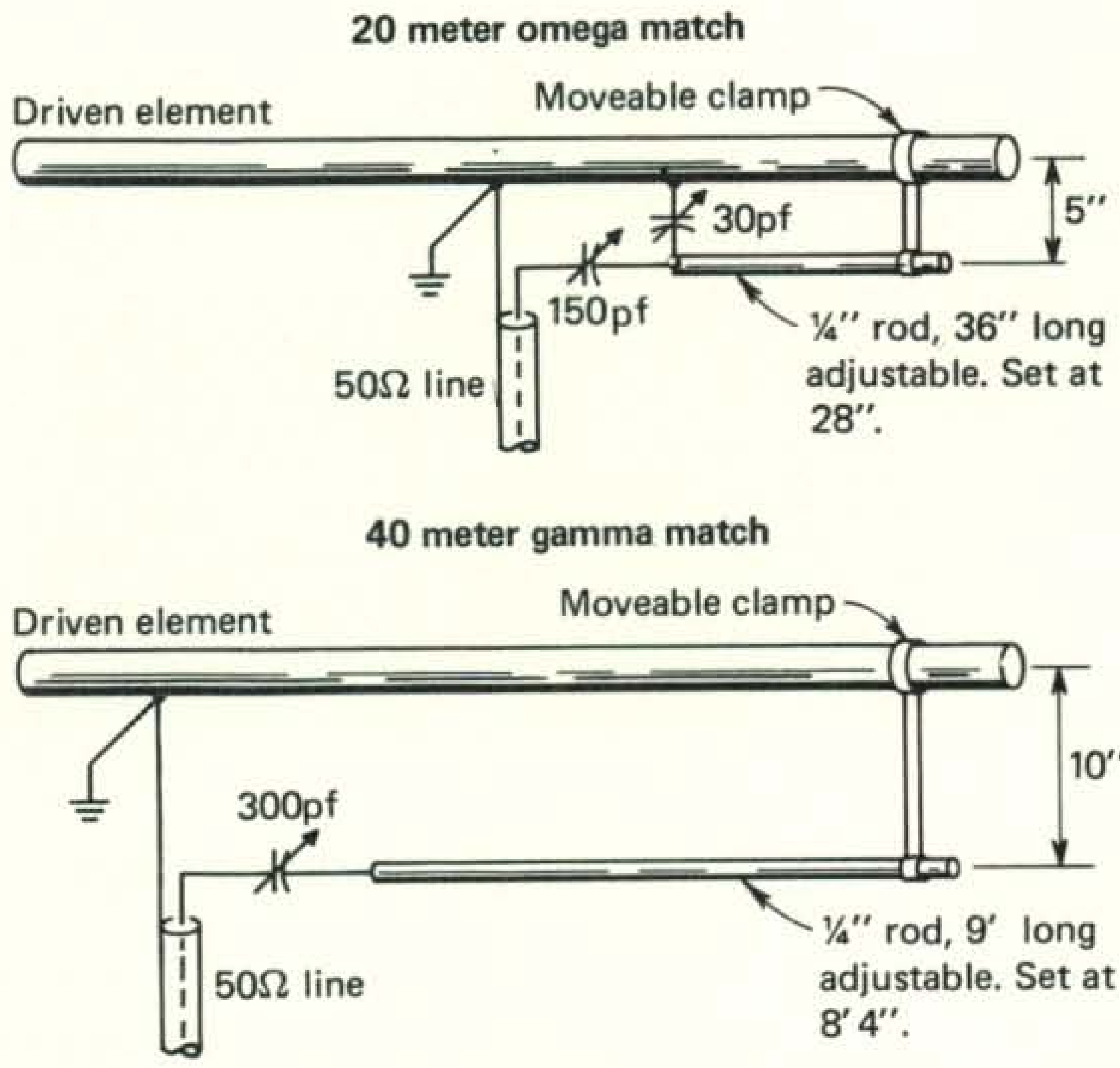


Fig. 8—Matching systems for 20-40 meter duo-band Yagi antenna.

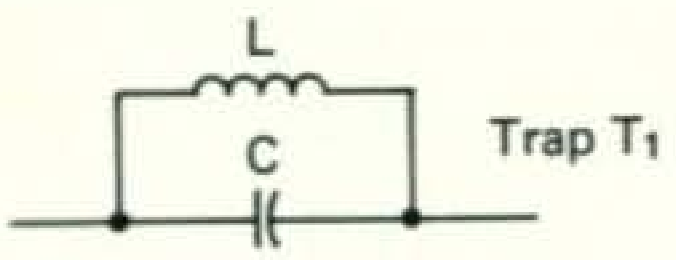


Fig. 9—Trap design for duo-band beam. The capacitor in original design is an aluminum cylinder that slips over the coil to serve as a rain shield. It is made of 2⅜" dia. tubing, 12" long. *L* is approx. 8 μh. 32 turns #20 e. 1⅜" dia. 7" long, space wound. C is 15 pf 10 kv. Adjust L to resonate at 13.8 MHz.

"The boom is 18 feet long. That provides 0.12 wavelength spacing for the 40 meter elements, which is just about right for a 2 element beam. On 20 meters, there are three elements. Spacing between the driven element and the director is 11′6" and spacing between driven element and reflector is 6′6". Those are commonly-used dimensions for a 3 element, 20 meter Yagi. The article claims 6.78 db gain on 14 MHz and 5.5 db gain on 7 MHz. Those figures sound reasonable to me."

"What about the mechanical construction?" asked Pendergast eagerly.

"Well, the elements are made up of aluminum tubing. The center sections are about 1¼" diameter and the elements taper down to ⅞" diameter at the tips. Boom diameter is 2½". All-metal construction is used.

"The two matching systems are shown in fig. 8. The 7 MHz matching device is a simple gamma match and the 14 MHz system uses an omega match. Both of these matching systems are discussed in my *Beam Antenna Handbook*[1].

"How about the traps?" queried my friend, as he wrote furiously in his notebook.

[1]Orr, "Beam Antenna Handbook," 4th edition. Radio Publications, Inc., Box 149, Wilton, Conn. $4.95 plus 25¢ postage and handling.

"The traps are all alike, and they are tuned to 13.8 MHz by using a grid-dip meter. The traps are adjusted before being put into the antenna.

"These traps are very interesting, as they are very low-C (fig. 9). That means the inductances are quite large—larger than one would suspect for an antenna of this type. This was done, I am sure, in order to decrease the length of the 40 meter tip sections. After all, the length of the 40 meter driven element is only 47′7" and the director is only 41′6". This is accomplished by using large inductors in the traps which tend to act as loading coils on 40 meters. If the traps had less inductance and more capacitance, the element tips would be longer. It's very simple; the more wire in the trap, the shorter the extension tip."

Pendergast thought a moment, then he asked. "How does this affect 20 meter performance?"

"As far as I know, it has no effect on 20 meter performance. Look at the s.w.r. curve for 20 meter operation (fig. 10). That certainly looks conventional. And the s.w.r. curve for 40 meters is very good, too (fig. 11). Since the element spacing is 0.12 wavelength, it is possible to achieve a relatively good bandwidth performance. Much better, in fact than many of the so-called miniature 40 meter beams on the market. This particular antenna was tuned for the Japanese phone band near 7025 kHz. It should be simple to shorten the tips of the 40 meter sections and move the resonant frequency of the antenna up into the top end of the band. In any event, the director element should be self-resonant about 150 kHz above the resonant point of the driven element for proper operation."

"That looks good," said my friend. "As long as the sunspot count is as low as it is, the interest in 40 and 80 meter DX antennas will remain high. Now, when will you come up with the design of a good, compact 160 meter rotary beam?" ■

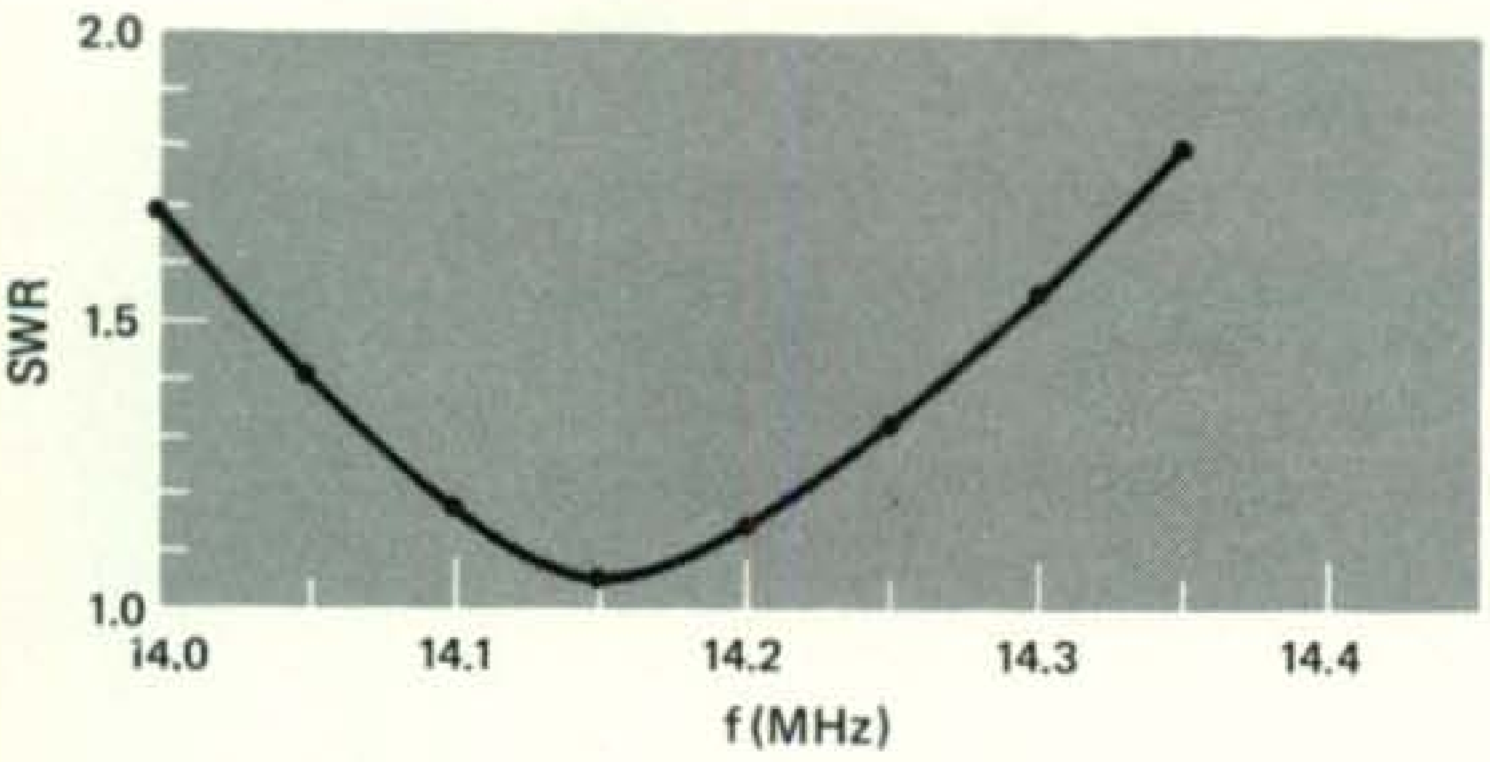


Fig. 10—s.r.w. plot for 20 meters for 40-20 meter Yagi beam.

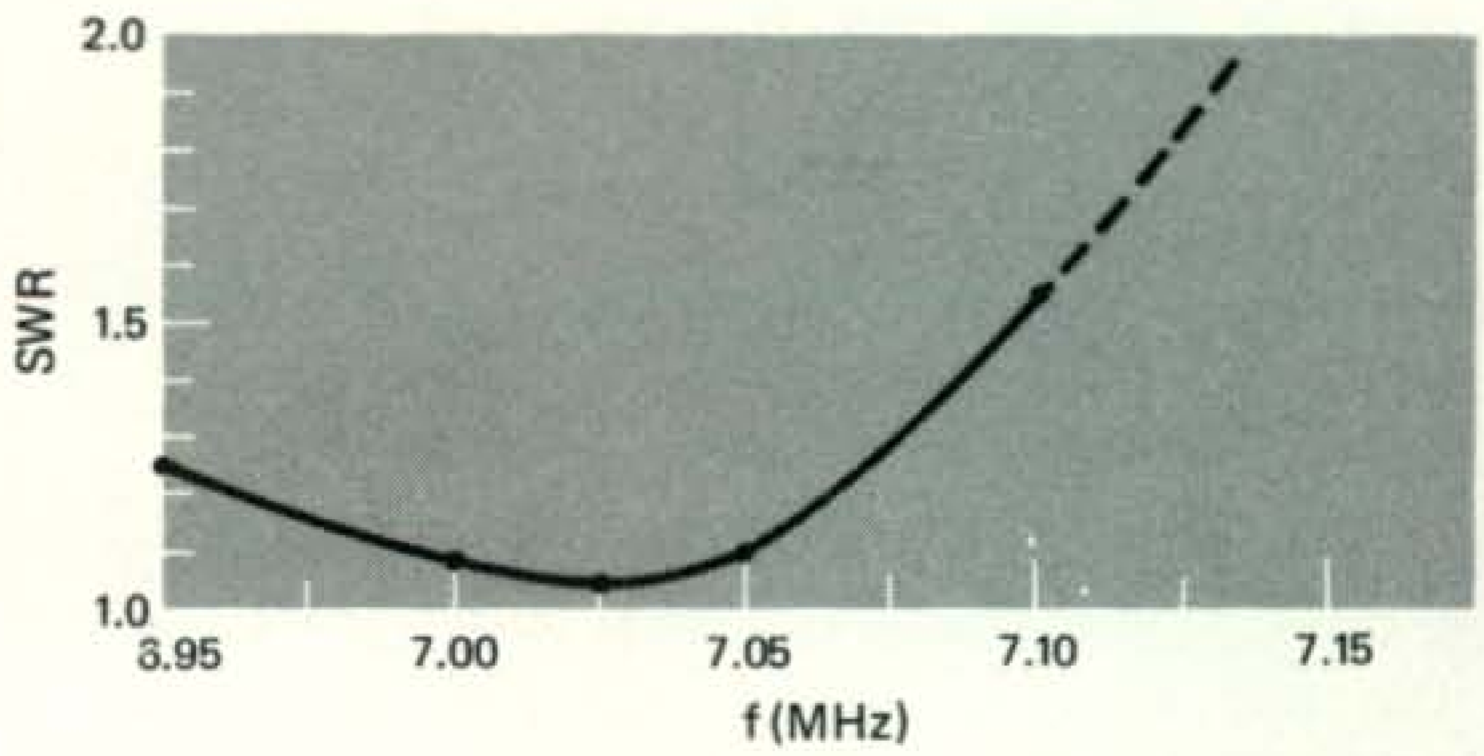


Fig. 11—s.w.r. plot for 40 meters for 40-20 meter Yagi beam.

antennas

BY WILLIAM I. ORR,* W6SAI

"Congratulations," said Pendergast, shaking my hand warmly.

"Thank you," I replied. "But what's the occasion?"

"Sixteen years ago this coming December our first adventure was recorded in *CQ* magazine. Do you remember *"Sunspot Madness or, the Day We Boiled the 304TL?"*

"I certainly do," I replied. "That story was about the sunspot madness that hits every DX-minded amateur on the day the sunspot cycle hits the absolute minimum. We're coming up on the sunspot minimum again, so it looks as if we'll have to beware of this terrible affliction."

"Right," said Pendergast. "The story should be a warning to all amateurs[1]."

"And now that we are at the bottom of the sunspot cycle, how does that affect antennas and DX?" I asked rhetorically.

*48 Campbell Lane, Menlo Park, CA 94025.

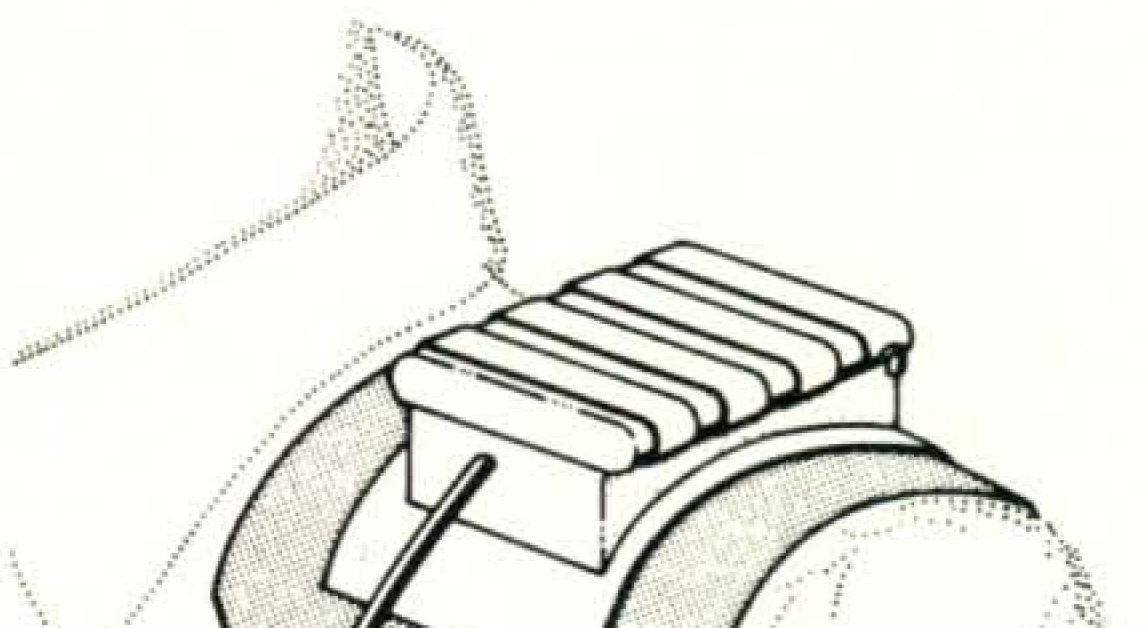


Fig. 1—The shoulder-mounted multi-turn v.h.f. loop antenna. This compact, low profile antenna is designed for shoulder mounting and is only about one-half inch high. It weighs less than 3 oz. and is used with a shaped "ground plane" which fits the shoulder of the operator. Used in conjunction with a microphone head-set, the antenna provides hands-free operation with the transceiver clipped to the belt. (Illustration courtesy of *Radio Communication).*

"More amateurs are interested in the low frequency bands—160, 80 and 40 meters and others have concentrated on the v.h.f. bands. I'll admit that 20 meters is crowded, but it is taking the overflow from 15 and 10 meters." Pendergast sighed. "All you have to do is look through the 1954 and 1965 copies of *CQ* and *QST* to see how DX was running at the bottom of the last two sunspot cycles. Then compare that information with copies of the magazines for 1958 and 1968, near the peak of the cycles."

"That's the reason for the increase in interest in the low bands and the v.h.f. bands," I said. "Antennas for those bands are of exceptional interest these days because that's where the action is . . ."

"What's new in v.h.f. antennas," asked Pendergast eagerly. "Hasn't everything been developed that can be developed. What's left to be new?"

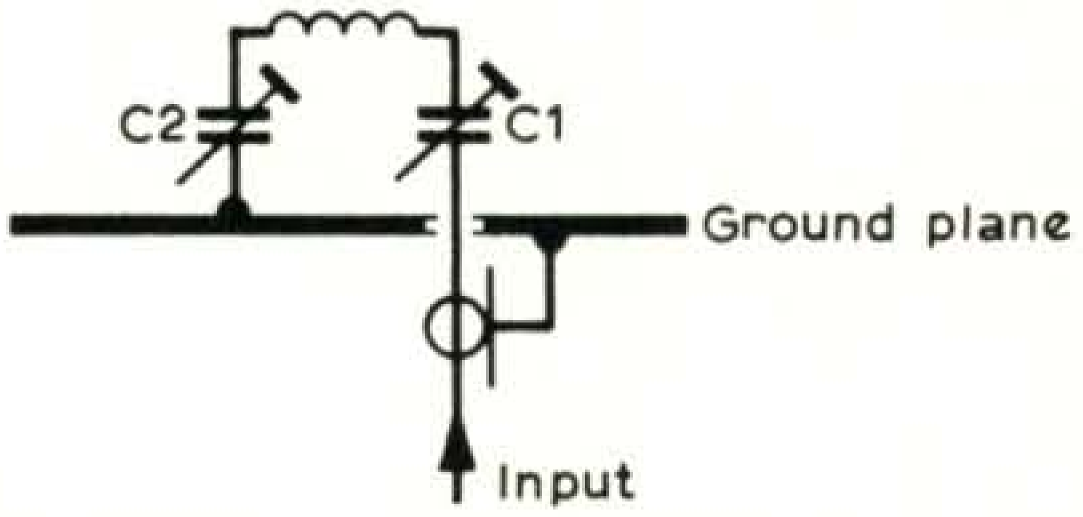


Fig. 2—Schematic of the multi-turn v.h.f. loop antenna. Capacitor C_1 is 0.35 pf to 3.5 pf and establishes the correct impedance to match the 50 ohm transmission line. Capacitor C_2 is 0.8 pf to 10 pf for tuning the antenna to resonance. For 150 MHz to 170 MHz the loop consists of 3.5 turns of ⅜-inch wide copper strap wound on a styrofoam form 2.7″ × 2.7″ × 0.7″ high. Slightly more inductance would be needed to tune the 144 MHz band. (Illustration courtesy of *Radio Communication).*

"Well, I found a very interesting v.h.f. antenna in the June, 1975 issue of the RSGB's *Radio Communication* magazine. It is a summary of an article in *IEEE Transactions on Antennas and Propagation,* March, 1975. The article concerns a workable and reliable antenna for personal handy-talkies or hand-held portable transceivers working in the v.h.f. region. The problem is to make an antenna that be placed so as to minimize absorption losses in the human body, which are quite high at those frequencies. Studies made in England in 1968 showed that when a v.h.f. antenna is close to the body or limbs of an operator, up to 90 percent of the signal may be lost. This problem

[1] For a free copy of "Sunspot Madness," send a self-addressed business-size (4″ x 9½″) envelope with 10¢ postage to the editor of this column, c/o EIMAC, 301 Industrial Way, San Carlos, CA 94070.

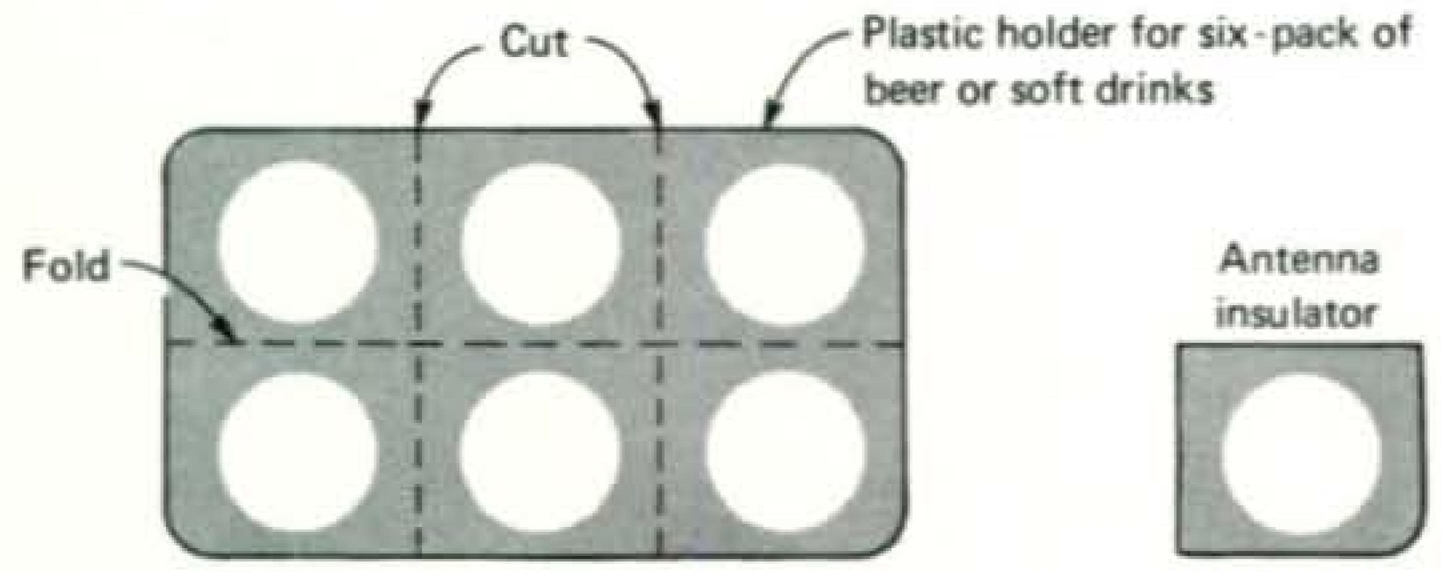


Fig. 3—The ecology-minded WA4BAX designed this antenna insulator to be made from the plastic holder for a six-pack! Cut it into three pieces and fold the sections back on themselves for double strength. The pull of the antenna distorts the circular plastic into a longish sort of loop whose strength is amazing. This is a great temporary antenna insulator for Field Day operation!

applies to the 'rubber duckie' antenna used with a lot of hand-held f.m. equipment."

"Rubber Duckie?" asked Pendergast with amazement.

"That's the name given to the flexible, helical wound antennas that are encased in black plastic," I replied. Pendergast rubbed his eyes and replied, "I guess I'm just not up with all the latest technical terms."

"To continue," I said, "the antenna described is a very compact, low-profile device for shoulder mounting that is just over one-half inch high (fig. 1). It is used with a 'shaped' ground plane that fits around the shoulder of the operator. The antenna is tunable over the range of 150 to 170 MHz, with a bandwidth of 1.4 MHz for an s.w.r. range of less than 3:1. No doubt it could be tuned down to 144 MHz.

"The antenna is worn on the shoulder and connected via a coaxial line to the equipment. It is possible to wear a jacket or coat over the shoulder antenna with only a little loss of efficiency; with a microphone headset and VOX it could provide completely hands-free operation if the equipment were carried in a pocket or clipped to the belt."

"Damned clever," muttered my friend. "What does the antenna consist of?"

"Our British cousins call it an *aerial,*" I replied. "In any case, it is a multi-turn loop wound on a styrofoam form measuring 2.7" × 2.7" × 0.7". The coil consists of 3½ turns of ⅜-inch wide copper strap. The coaxial cable and tuning and matching capacitors are assembled on a metallic ground plane which is extended by a 4½" × 6½" 'counterpoise' plate shaped to fit the shoulder. The schematic of the antenna is shown in fig. 2.

"Detailed radiation patterns in the *IEEE Transactions* show this unit has an average gain of 3.8 db over a shoulder mounted 6.6" helical-wound whip ('rubber duckie'), which in itself is roughly 5 db down on a full size ¼-wave whip.

"A disadvantage compared with the helical antenna is the restricted band width, which calls for careful tuning. This should be done with the antenna in position on the shoulder (requiring an assistant or a contortionist!) though there is little change in tuning adjustment from person to person so it can be tuned on someone else. It is also shown that better results are achieved with the loop axis running fore and aft, as shown, rather than directed sideways along the shoulder. Polarization is primarily vertical."

"How would you tune the gadget up?" asked Pendergast.

"I would surmise that a combination of an s.w.r. meter in the coaxial line, plus a field strength meter would do the job," I replied.

"Great," replied Pendergast, as he made notes in his black notebook. "Now, do you have anything in your mail box for the so-called d.c. bands?"

"I certainly do!" I replied. "Dave, WA4BAX, is the Hero of the Month. I just received a letter from him in which he solves both the ecology and antenna insulator problems with one amazing stroke of genius! He's made the earth-shaking discovery that a plastic holder for a six-pack of beer can be cut up into three parts, folded back on itself and—presto! you have three antenna insulators at no cost! Look at fig. 3."

Pendegast squinted at the drawing. "You've got to be kidding," he stated.

"No, sir," I responded. "Dave sent me a sample insulator and it works fine. You can't tear it apart. It's very strong. And the plastic is polyethylene, which is a very good r.f. insulator. So

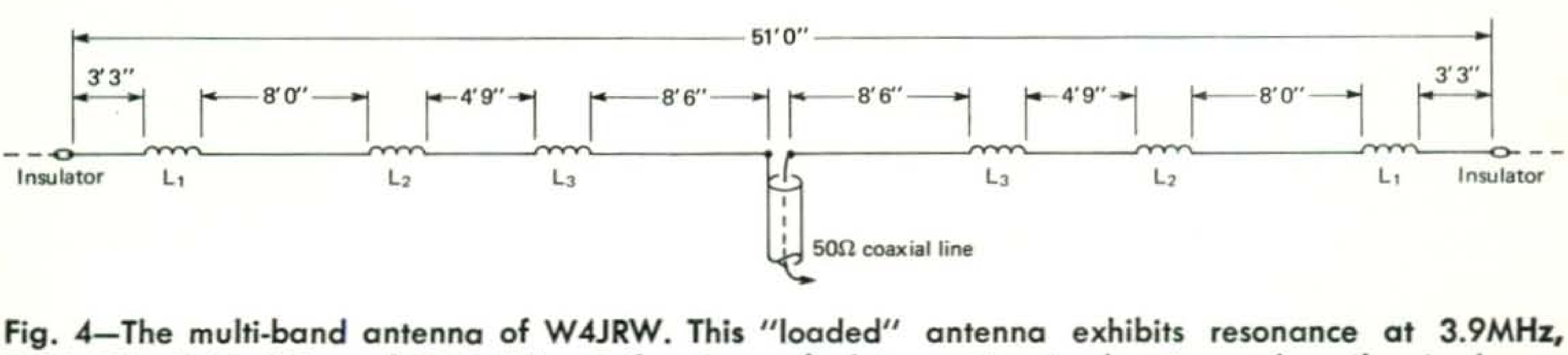


Fig. 4—The multi-band antenna of W4JRW. This "loaded" antenna exhibits resonance at 3.9MHz, 7.25 MHz, 14.2 MHz and 28.6 MHz. Coil pairs marked L_1 art 81 microhenries each, coil pairs L_2 are 25 microhenries each, coil pairs L_3 are 7 microhenries each. Each coil is approximately 3 inches long. Overall antenna length is 51 feet.

from each six-pack, you get three free antenna insulators for a wire antenna."

"Well, I'll be dipped," mused Pendergast. "Think of all the plastic holders I've thrown away."

"Before you rush out and buy a six pack, you might be interested in a note I received from Bill, W4JRW. I commented on some of his interesting work with loaded dipoles in my July antenna column. Bill has been playing with an experimental dipole antenna using loading coils that exhibits resonance on 10, 20, 40 and 80 meters (fig. 4). The dipole is only 51 feet long and is center-fed with a 50 ohm coaxial line. Three loading coils are used in each half of the antenna. The self-resonant frequencies are 3.9 MHz, 7.25 MHz, 14.2 MHz and 28.6 MHz."

"Too bad it doesn't work on 15 meters," observed Pendergast.

"It's a cut-and-try operation," I replied. "If you want to take additional time and you are an avid experimenter, no doubt the design could be altered to accept 15 meters."

"It sounds just like the thing for Field Day," admitted Pendergast. He paused a moment, then asked, "Has the mailman brought any interesting letters?"

"A few," I replied. "I am still getting feedback from the discussion on vertical versus horizontal antennas. Obviously many fellows, such as WA7-YRP are having a lot of luck with well-made vertical antennas. Alan has a short vertical, such as described in the March, 1974 issue of *QST*. Basically, it is a four-band job for 40, 20, 15 and 10 meters. It is placed in the center of a 10 by 25 foot patio. He uses 70 radial wires. This modest and compact antenna has accounted for 42 countries on 40 meters, 95 on 20 meters, 55 on 15 meters and 20 on 10 meters during the past 10 months! That's not bad at all, considering the state of the sunspot cycle. Alan says, "With a little good skip I can often crack the pile-ups and I have no shortage of wallpaper in the shack." So, you see, the battle isn't over. And the fellow that said the vertical antenna is one that radiates poorly in all directions will have to eat his words."

"Well," said Pendergast, "it looks as if there's no definitive answer to the question of horizontal versus vertical. Isn't that the provocative question you have run across?"

"No, it isn't," I replied. "The greatest mystery to many amateurs seems to be in the area of standing wave ratio. That still confuses a great many amateurs. I thought when Walt Maxwell, W2DU, ran his fine series of articles in *QST* that the s.w.r. problem had been put to rest for good. But that isn't the case at all. There's even flak over Walt's article, as you've probably seen in the August issue of *CQ*.

"Well, why worry about s.w.r. at all?" queried Pendergast. "If the antenna works, it works. I think the s.w.r. meter is the invention of the devil. All it does is confuse the issue. My motto is: don't bother me with the facts—my mind is made up."

"The s.w.r. meter can certainly serve a useful propose," I replied, "But some amateurs make a fetish out of their s.w.r. reading."

"Look at this," said my friend, flinging an instructional manual across the table to me. "Here's an instruction book for a linear amplifier. The manufacturer states that the amplifier is to be run into a 50 ohm load with the s.w.r. not to exceed 2-to-1. Why? What will happen at 2.1-to-1? Or at 5-to-1? Will the amplifier explode at a high s.w.r. reading? Or will your report drop from S9 plus to S6 in Outer Baldovia?"

"It may seem obscure, but there are very good reasons why manufacturers state the maximum

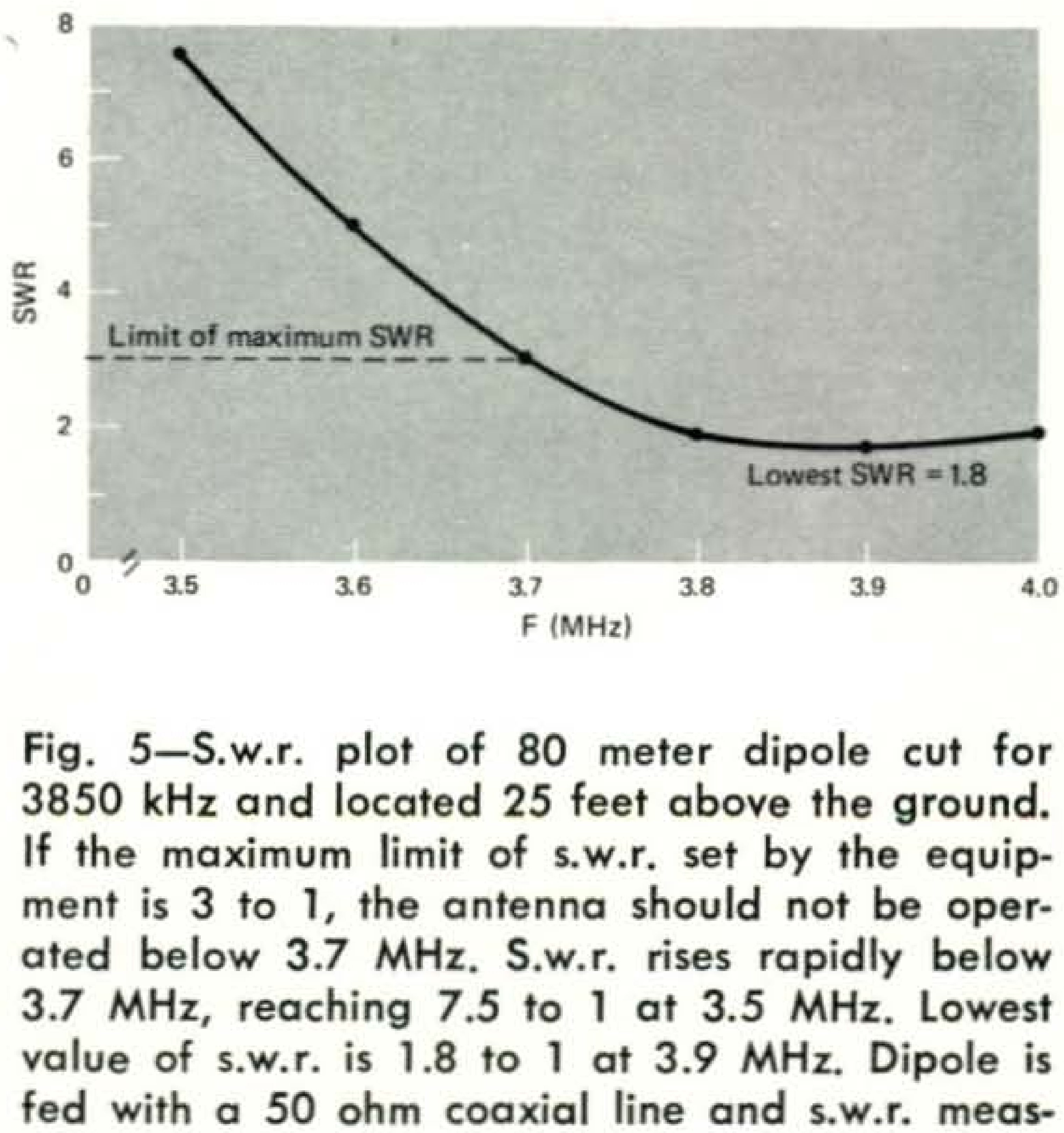


Fig. 5—S.w.r. plot of 80 meter dipole cut for 3850 kHz and located 25 feet above the ground. If the maximum limit of s.w.r. set by the equipment is 3 to 1, the antenna should not be operated below 3.7 MHz. S.w.r. rises rapidly below 3.7 MHz, reaching 7.5 to 1 at 3.5 MHz. Lowest value of s.w.r. is 1.8 to 1 at 3.9 MHz. Dipole is fed with a 50 ohm coaxial line and s.w.r. measurements were taken at the station end of the line, which is about 150 feet long. Changing line length will not change the value of s.w.r. on the line.

s.w.r. limit for their equipment. One reason is that when the equipment is operated into a high value of s.w.r, it may not tune properly. It's possible to run right off the scale of the loading control of an amplifier if the antenna presents a high s.w.r. at the equipment. Then, again, a high value of s.w.r. may lead to flash-over in the amplifier. If the network voltage is too high at the antenna terminals, the output loading capacitor of the pi-network may flash over. If the amplifier is underloaded, the peak plate voltage may flash over the tuning capacitor. And, if the amplifier employs a screen grid tube, the screen dissipation may be exceeded if the amplifier is improperly loaded."

"What about a grounded grid amplifier?" demanded Pendergast. "There are plenty of them,

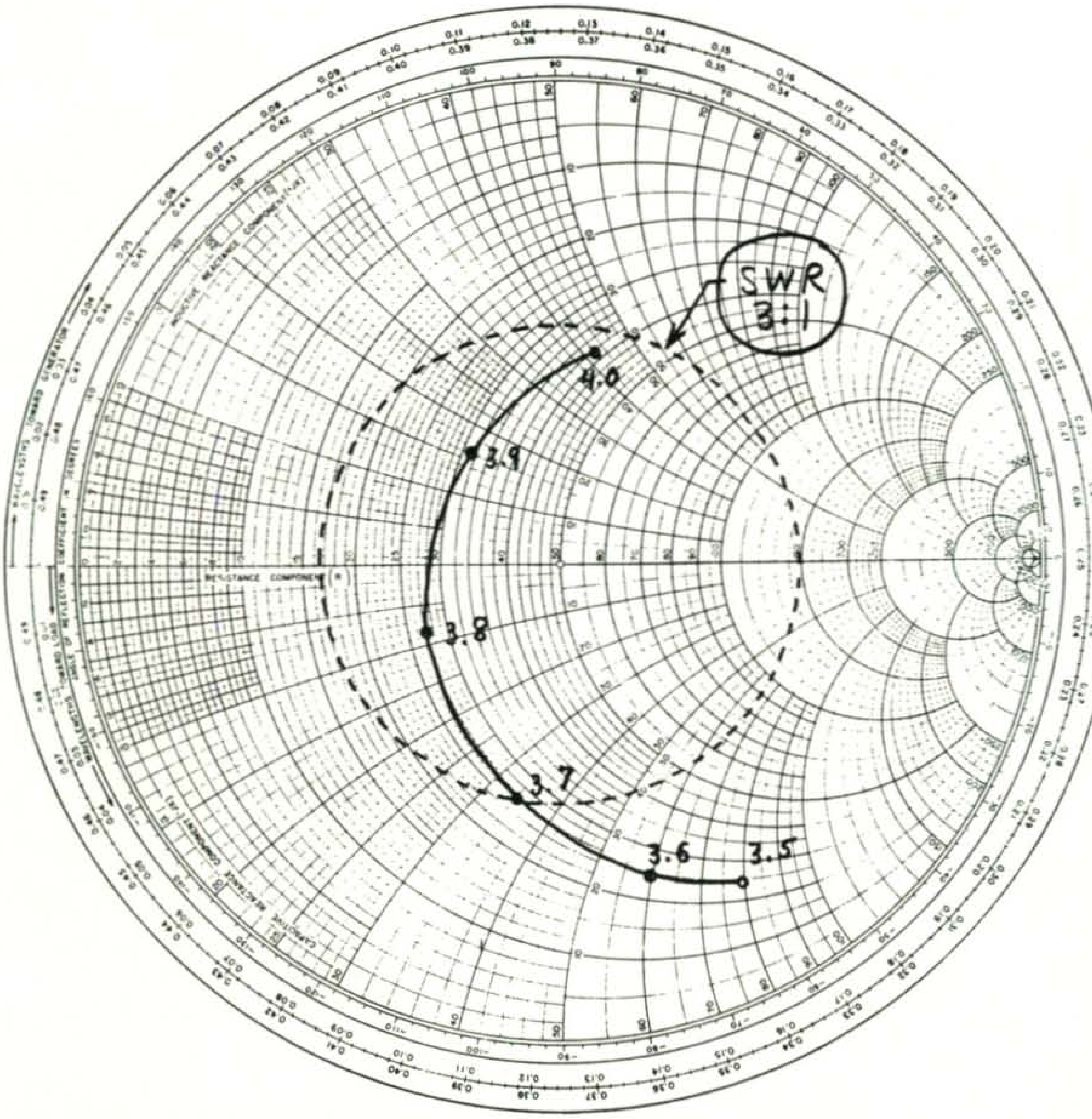


Fig. 6—Smith Chart plot of the 80 meter dipole of fig. 5. The 3 to 1 s.w.r. circle is drawn on the chart. The resonant frequency of the dipole is about 3830 kHz, the point the curve passes through the resistive axis (X-axis) of the chart. Below this requency, the antenna appears as a resistive-capacitive reactance at the input end of the line and above this frequency the antenna appears as a resistive-inductive reactance. At resonance, the antenna exhibits a load of about 28 ohms. At no point in the 80 meter band does the antenna present a 50 ohm load and range of operation is limited to the frequency span of 3.7 MHz to 4.0 MHz, within the 3 to 1 s.w.r. circle.

using 3-500Z's. What happens to the tubes when the amplifier is operated into an antenna having a high standing wave ratio?"

"If the amplifier can be properly loaded into the antenna, nothing will happen," I replied. "Trouble can arise if the amplifier is loaded up into an antenna having a high s.w.r, and if the operator shifts frequency *without retuning* the amplifier. If this is done, the amplifier becomes improperly loaded. In addition, the plate circuit is out of resonance. This can lead to dangerously high levels of grid current for an underloaded condition or flat-topping in an overloaded condition.

"It is best to have a relative low s.w.r. on the antenna system. By that, I mean 3 to 1, or less. But it is not imperative to beat your brains out for a 1 to 1 ratio. Even if you get it, the s.w.r. will rise as the antenna is operated off the design frequency.

"Where you really run into trouble is on 80 meters, where the width of the band is large in comparison to the frequency. Very few 80 meter antennas will show a low value of s.w.r. across the band. And since most of them are close to the ground in terms of wavelength, the radiation resistance is very low. Look at fig. 5. This is the s.w.r. plot of an 80 meter dipole about 25 feet above the ground. That's a typical antenna. The best value of s.w.r. is about 1.8 to one. And you can see the reason for this when the antenna is measured with a *General Radio RF Bridge* (fig. 6). Look at the plot on the Smith Chart."

"Smith Charts make me nervous," observed Pendergast in a mild voice.

"They tell you a lot more than an s.w.r. meter," I replied. "In this instance, the dipole is

[*Continued on page 80*]

age of CR_9 (plus the junction voltage of Q_2 and the SCR) is exceeded. Q_2 then drives the SCR into conduction, which places a short across the filter capacitor, blowing the fuse at the input to the regulator circuitry. The fuse used here should be rated at no more than half again the full load current. The CR_9-Q_2-SCR combination used in our unit fired at 2.2 volts above the zener voltage of CR_9, due to the internal junction potentials of Q_2 and the SCR. This "firing voltage" should be checked, using a variable voltage source (which could be made up of several batteries of 1.5-6-9-12, etc. voltages). Be sure to put a 10 to 100 ohm resistor in series with the anode of the SCR during the tests so you can use a meter to see when the anode voltage of the SCR drops to zero, instead of a disintegrating fuse.

Performance

From no load to 2a., the voltage drop on both high power units is less than 0.1v., and between no load and 15a. is approximately 0.2v.—just as good as an auto-type storage battery. Ripple at full load is insufficient to cause any hum in the low level audio circuits when the supply is delivering 180 watts.

The two "low-power" 5a. units, when used with 10 watt output rigs drawing about 3a., were sufficiently well regulated to show "less than a needle's width" regulation between transmit and receive.

All new parts for the high power supply (17a.) would run close to $65, which is a bit high, and would probably warrant purchasing a readymade unit. However, a quick look through the surplus catalogs, the Poly-Paks ads, etc., shows that the supply can be produced for approximately $15, not bad when you consider the cost, inconvenience, and possible safety problems of a battery/charger combination. Both the prototype and the MK1 version weigh considerably less than the battery W4FJ had under his desk powering his high power f.m. rig. W4ZSH and W4JHK built 3 to 5a. supplies for "mobile" f.m. rigs, for less than $5, using judicious "flea market" purchases and raids on several friends' junque boxes. ■

Antennas [*from page 26*]

seen to have a radiation resistance value of about 28 ohms at 3830 kHz. At 4.0 MHz, the radiation resistance is nearly 40 ohms, but the antenna presents a high value of inductive reactance at the input end of the feedline. At 3.5 MHz, the radiation resistance is 25 ohmns, and the antenna appears highly capacitive. Note that the 3 to 1 s.w.r. circle is drawn on the graph. If you stay inside that, your range of antenna operation is limited to the 300 kHz span from 3.7 MHz to 4.0 MHz."

"Well, how do you lower the s.w.r. on this particular antenna? Can you get it to work across the whole band," demanded my friend.

"As a starter, I suggest you get the November, 1974 issue of *CQ* and read *"Impedance Measurements at Radio Frequencies,"* by K4KJ. Then read *"How to Use the Smith Chart,"* by W1DTY in the November, 1970 issue of *Ham Radio* magazine. In addition, there was a good article in the January and February, 1966 issues of *QST* by K1PLP on Smith Chart calculations. All of these are recommended reading. Finally, *CQ* had a two-part article by W7RGL on antenna impedance matching in the November and December, 1963 issues. You might be able to pick these up at a library, or get copies from some of the fellows that sell back-dated magazines in the classified columns. In any case, all of these articles are very good reading for the amateur who wants to know more about the workings of his antenna."

"Do you have to use a Smith Chart?" Pendergast asked suspiciously.

"Don't be afraid of the Smith Chart," I replied. "It might look confusing to those who have not used it, but it is relatively simple. A variation of the Smith Chart was used by astronomers and navigators at the time of Columbus. So there's nothing new about it. Sometime when you are in a more relaxed mood, I'll give you a quick rundown on this interesting and very useful device." ■

Repeater [*from page 38*]

after a lengthy period of having your nice, open-access repeater keyed up by squatters using those machines with no regard to tripping yours, you go to tone access. Holy mackerel, the howl *that* action raises from amongst the troops! But it was either keyed-access or shut it down just to comply with the requirements of the law, let alone reducing the irritation factor to a livable level. It is at this point that you begin to tell other people: If you are thinking of building a repeater, for heaven's sake, DON'T. ■

Epoxy Cement [*from page 40*]

How to work with Epoxy

For small work, hardening time is 24 hours, preferably longer for larger globs of cement. It becomes tacky in three hours but keeps on flowing for another ten hours. You must take advantage of these three stages to produce the correct or preferred bulge or contour in the right place

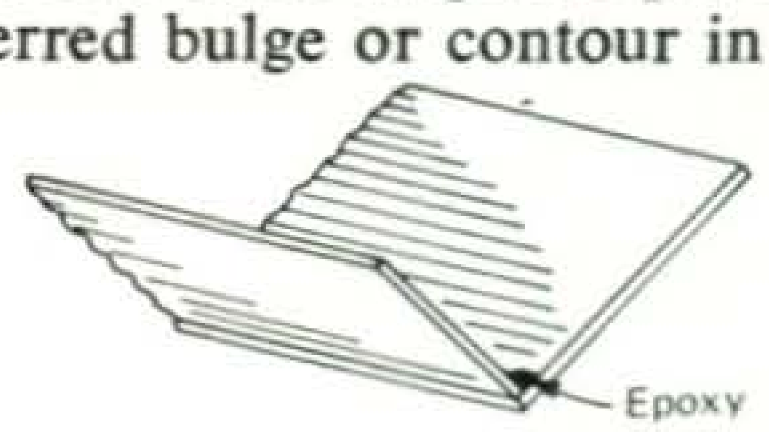


Fig. 12—Let epoxy flow while holding work at desired angle.

antennas

BY WILLIAM I. ORR,* W6SAI

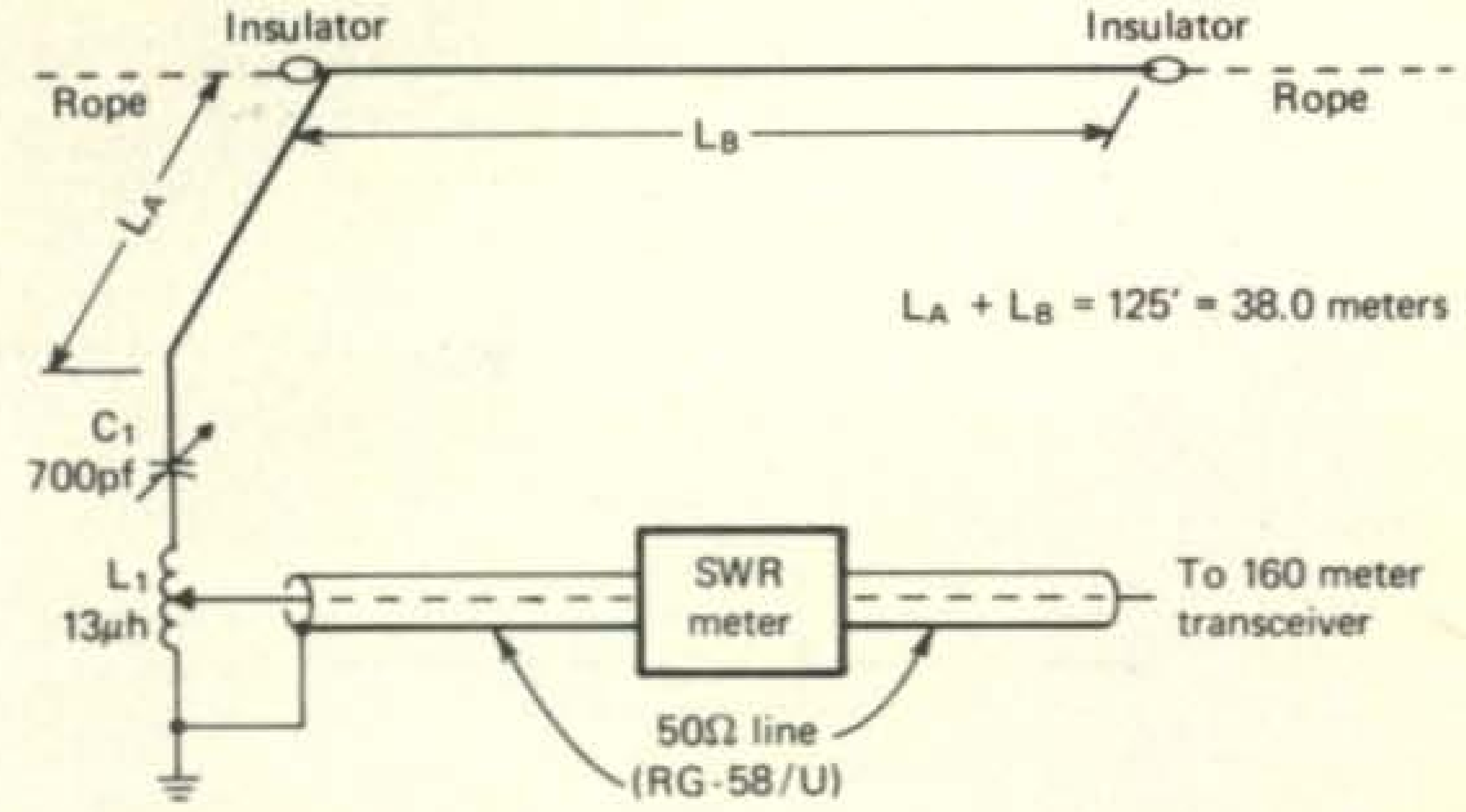


Fig. 1—Typical Marconi antenna for 160 meter band. Capacitor C_1 is a two section broadcast type. Coil L_1 is 20 turns of #20 tined wire, 2" diameter, spaced to 2" long. Adjust capacitor for maximum loading and tap on the coil for minimum s.w.r. See text for information on ground connection.

"Holiday Greetings to you!" I exclaimed. Pendergast struggled up the walk carrying a large box. His eyes were bright and his cheeks were rosy and his breath made a cloud of smoke about his head in the frosty air. Puffing, he struggled the box through the door and dropped it with a thump on the operating table.

"Thank you. And the same to you! Look what I found under the Christmas tree," he exclaimed. Taking a screwdriver from the table, he expertly slit the tape on the box top, opening the carton like a flower.

"It's a transceiver," I said, peering into the box. "Right off the boat from Japan."

"A *Kamikaze 1000,*" said Pendergast proudly, as he pulled it out of the box and ripped off the plastic cover. "It will work all bands from 160 meters to 10 meters."

"Does it cover 11 meters?" I inquired.

Pendergast peered at the bandswitch. "Yes," he admitted. "It has an 11 meter position on the switch."

"Well, Ten-Four, old Buddy, and have a lot of fun. May all your reports be wall-to-wall and tree-top-tall."

"What kind of gibberish is that?" demanded my friend. "The reason I got this transceiver is that it has the 160 meter band on it. And now the question is: can we have a discussion about 160 meter antennas without reference to the 11 meter position on the bandswitch?"

"Of course," I replied. "I was only pulling your leg."

Pendergast quickly leafed through the instruction manual. "It says in here that a nominal 50 ohm load is required on all bands."

"That can be accomplished," I replied. "However, a few facts about 160 meter antennas in general are not amiss. As you know, the band is divided into segments, the most-used one being the 1800-1900 kHz segment, in which amateur operation is authorized in most of the United States. Some areas are allowed to operate in 1900-2000 kHz, and various foreign countries restrict 160 meter operation to skinny, 10 kHz slices of the band. All this is done because the 160 meter band is shared with Loran in most of the world, and is also used for the Maritime Mobile Service in other areas of the world".

"Let's talk about the 1800-1900 kHz assignment," said Pendergast.

"Very well," I replied. "To start with, a dipole antenna cut to the center of this assignment, or 1850 kHz, is about 253 feet long. If it is mounted at a reasonable height above ground, say, 30 to 50 feet, the radiation resistance will fall in the range of 15 to 30 ohms. Most amateurs don't have the

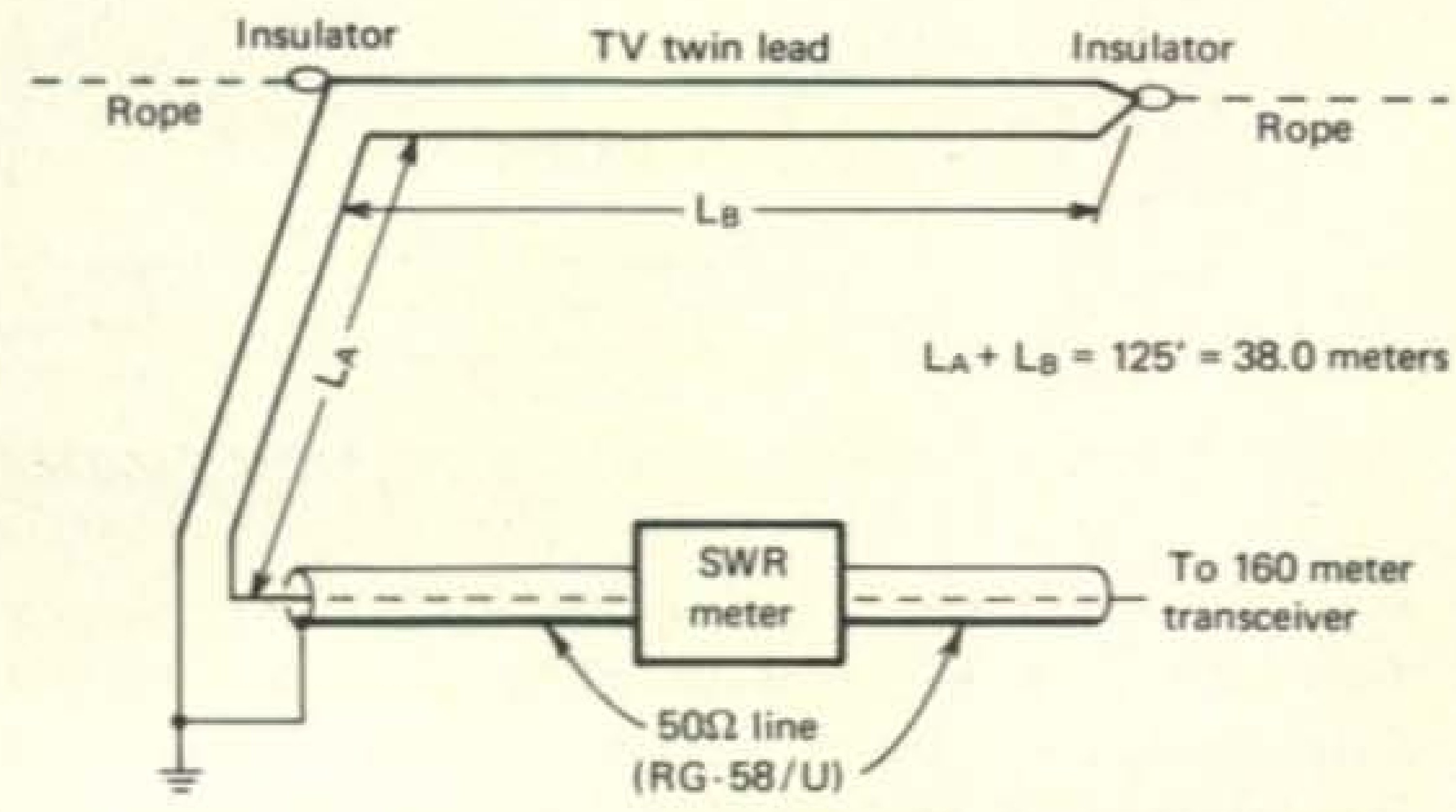


Fig. 2—Folded Marconi antenna for 160 meters. Antenna is made of TV-type twin lead. Antenna leads are joined at far insulator. At the input end, one wire is grounded the other is fed by a 50 ohm coaxial line.

*48 Campbell Lane, Menlo Park, CA 94025.

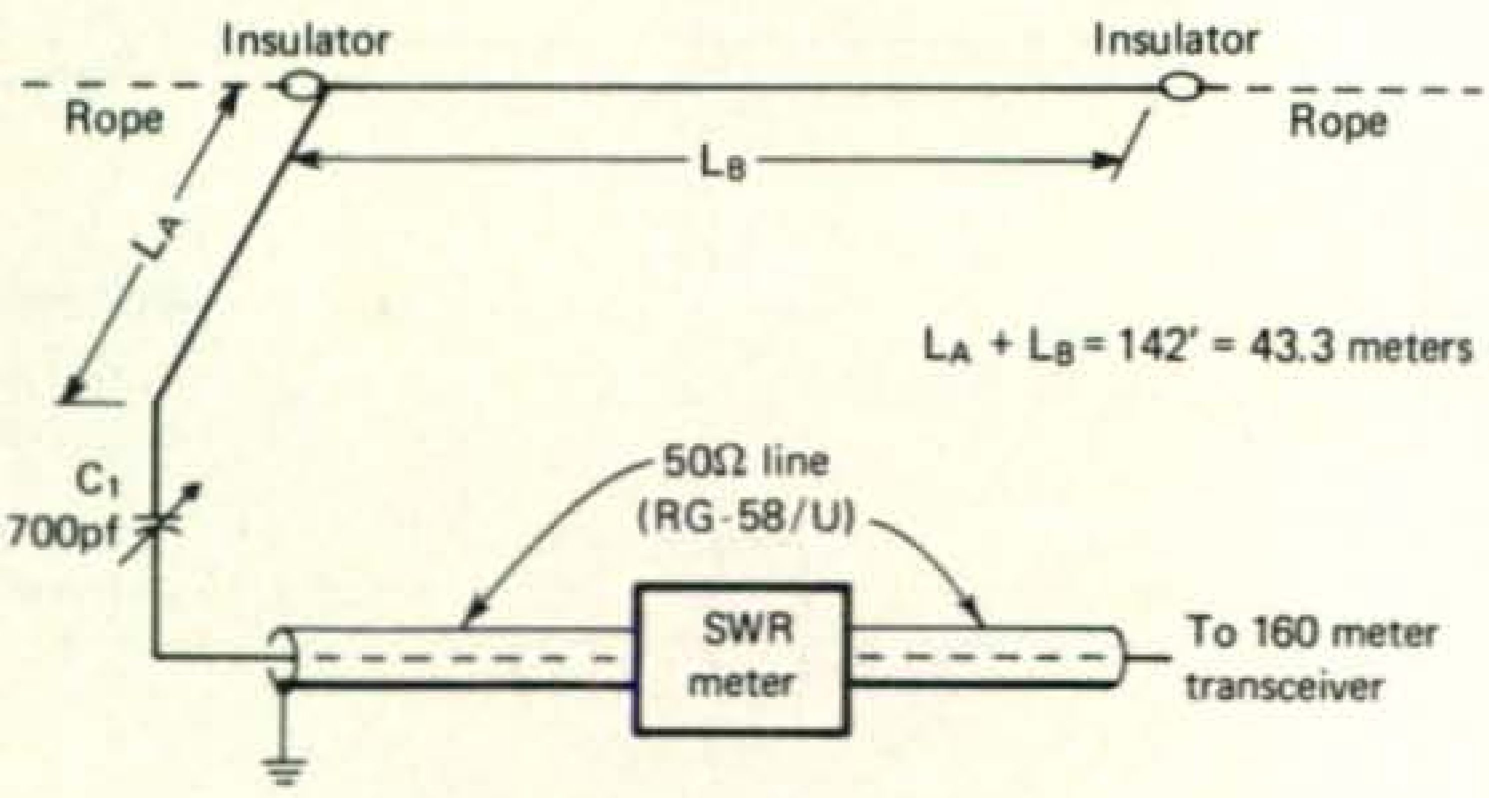


Fig. 3—Extended Marconi antenna for 160 meters. Antenna length is extended beyond quarter wavelength so as to raise input impedance. Antenna reactance tuned out by capacitor C_1.

acreage to put up an antenna of this size, so they start thinking about either a Marconi antenna or a vertical antenna of some sort."

"Right!" exclaimed Pendergast. "How about a simple, wire antenna running from the house to a nearby, convenient tree?"

"You can do it," I replied. "Look at fig. 1. This is just about the simplest 160 meter antenna you can build. It is a Marconi antenna designed for coaxial feed from a 50 ohm line. The flat-top, or antenna wire, is about 125 feet long and is series-tuned to resonance against ground. The coaxial line is tapped on at an appropriate point on the coil to make a good impedance match. The

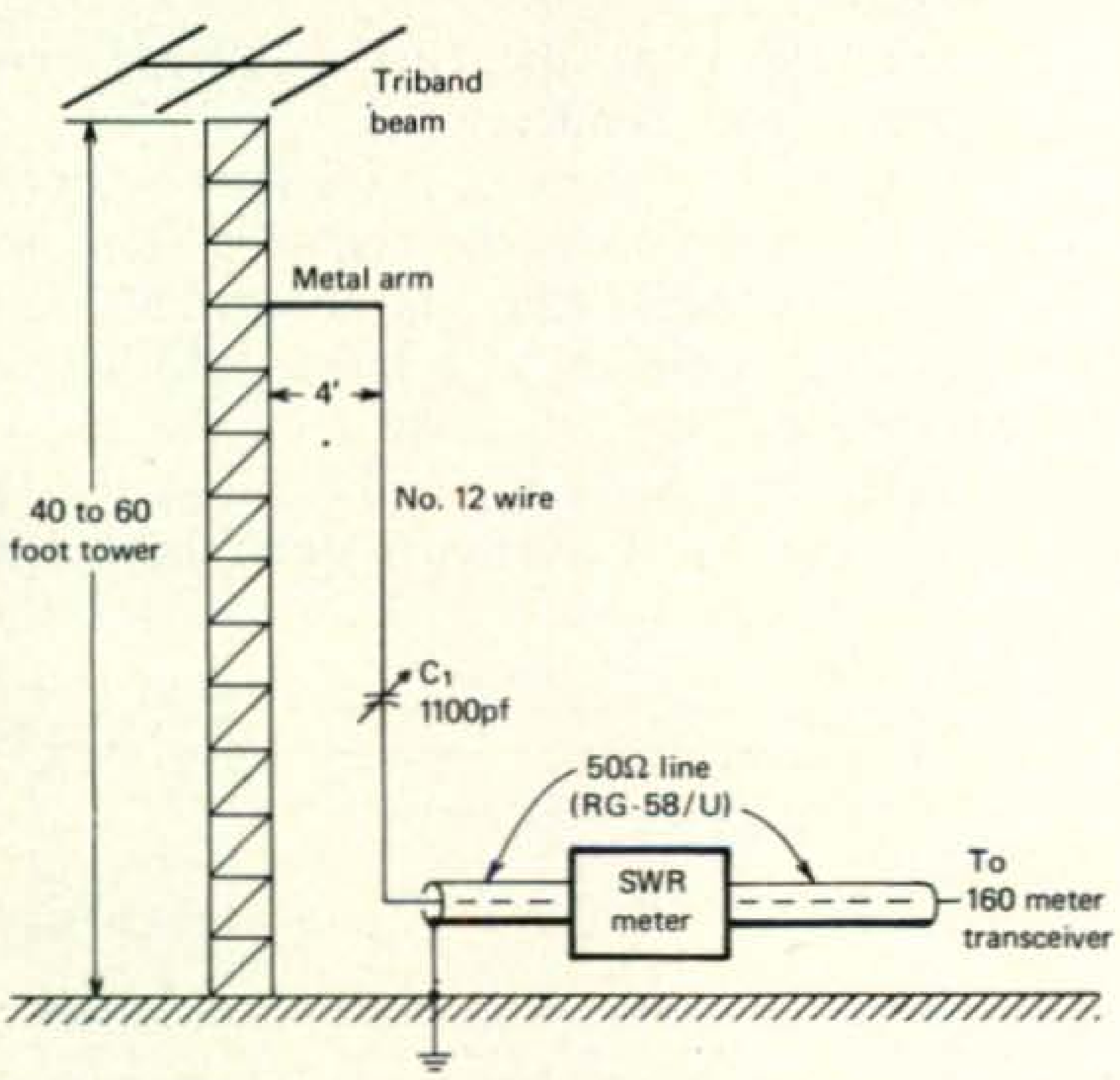


Fig. 4—Gamma-fed tower for 160 meter operation. Place metal arm at 80% of tower height. Capacitor C_1 is three-section broadcast type. Adjust placement of arm and length of gamma wire for lowest s.w.r. on transmission line. Control leads to rotor and indicating device should be brought to ground level and each lead bypassed to ground with a .01 mf disc capacitor before being led away from the tower.

capacitor is adjusted for maximum loading and the tap is adjusted for the lowest value of s.w.r. on the line."

"What about the ground system?" asked Pendergast as he scribbled in his notebook.

"The ground is an important part of the antenna," I admitted. "The radiation resistance of the Marconi antenna runs close to 10 ohms when the flat-top runs parallel to the ground at a height of about 35 feet. If the antenna is vertical, the radiation resistance runs close to 35 ohms. Most hams can't put up a vertical antenna that tall, so they settle for one that is mostly horizontal. All ground losses and circuit losses are in series with the antenna circuit, and they usually total up to more than 10 ohms. For best results, the best ground possible must be used."

"What do you use for a ground with this antenna?" asked my friend.

"I use a very short connection to the cold water system in the house, which is copper pipe. In addition, I have a second, heavy wire running to the lawn sprinkler pipes, plus two ground rods each about 5 feet long driven into the soil outside the shack window . . ."

"That sounds like a pretty good ground to me," objected Pendergast, drawing a multiplicity of little ground symbols in the margin of his notebook.

"Yes, pretty good. But I improved it by adding two quarter-wavelength radial wires at the common ground point. They were each 125 feet long and looped through the yard, through the hedges and bushes and along the house, about a foot or two clear of the ground. The radials cut my ground resistance in half. It is about 15 ohms now."

"That means you are still losing over half your output power in your ground connection," shouted Pendergast.

"Right. Ground losses are one of the big problems with short antennas, or antennas located close to the ground. Run-of-the-mill ground connections exhibit resistance values as high as several hundred ohms, and a ground loss resistance of only 15 ohms is not so bad."

"Isn't there anything you can do about that? It still sounds wasteful of power to me," objected Pendergast.

"One stunt that can be done is to increase the radiation resistance value of the antenna," I replied. "Look at fig. 2. This is half of a folded dipole, working as a Mar-

coni antenna. Since equal, in-phase currents flow in each wire, a step-up in impedance is obtained, just as in a folded dipole. For a Marconi antenna of this type, in close proximity to the ground, the input resistance is about 40 to 50 ohms. That provides a good match without auxiliary networks to modern s.s.b. equipment and at the same time, reduces the ground loss by a factor of four."

"You could make the flat-top out of 300 ohm TV ribbon line," observed Pendergast.

"A lot of fellows do just that," I replied. "And there's still another way to raise the input resistance of a simple Marconi antenna. Just make it longer than a quarter-wavelength. As you increase the length beyond quarter-wave resonance, the input resistance climbs quickly . . . as does the antenna reactance. The length is increased to about 142 feet (fig. 3) and a series capacitor is used to tune out the inductive reactance of the antenna. No loading coil, or other matching device is needed. The length of the antenna can be trimmed, or lengthened, a bit at a time so as to produce a 50 ohm load when the series capacitor is adjusted for the lowest s.w.r. on the transmission line to the equipment. If you don't want to fiddle around with antenna length, a very small series coil placed between the capacitor and the antenna will suffice. Just adjust the number of turns on the coil while maintaining resonance with the capacitor and shoot for lowest s.w.r. on the feedline to the transmitter."

"What about a good vertical antenna for 160 meters?" asked Pendergast. "I understand that some of the best top-band DX operators use vertical antennas."

"That's right. It has been pretty well proven in the 160 meter Trans-Atlantic tests and during contests that the vertical antenna has a distinct DX advantage over the low, horizontal antenna. Most 160 meter verticals, by the way, are compromise antennas as very few amateurs can erect a full, quarter-wavelength vertical antenna. One popular scheme is to use the h.f. regular tower and beam as a top-loaded vertical antenna. A forty to sixty foot high tower, loaded at the top by a tri-band beam makes a very effective vertical antenna for 160 meters. The tower is fed by a gamma match wire (fig. 4). This is a good scheme and works well, *provided* you keep the r.f. out of the control wires to the beam rotor and direction indicator. There's a good article about all of this in the October, 1975 issue of *QST* by W5RTQ.

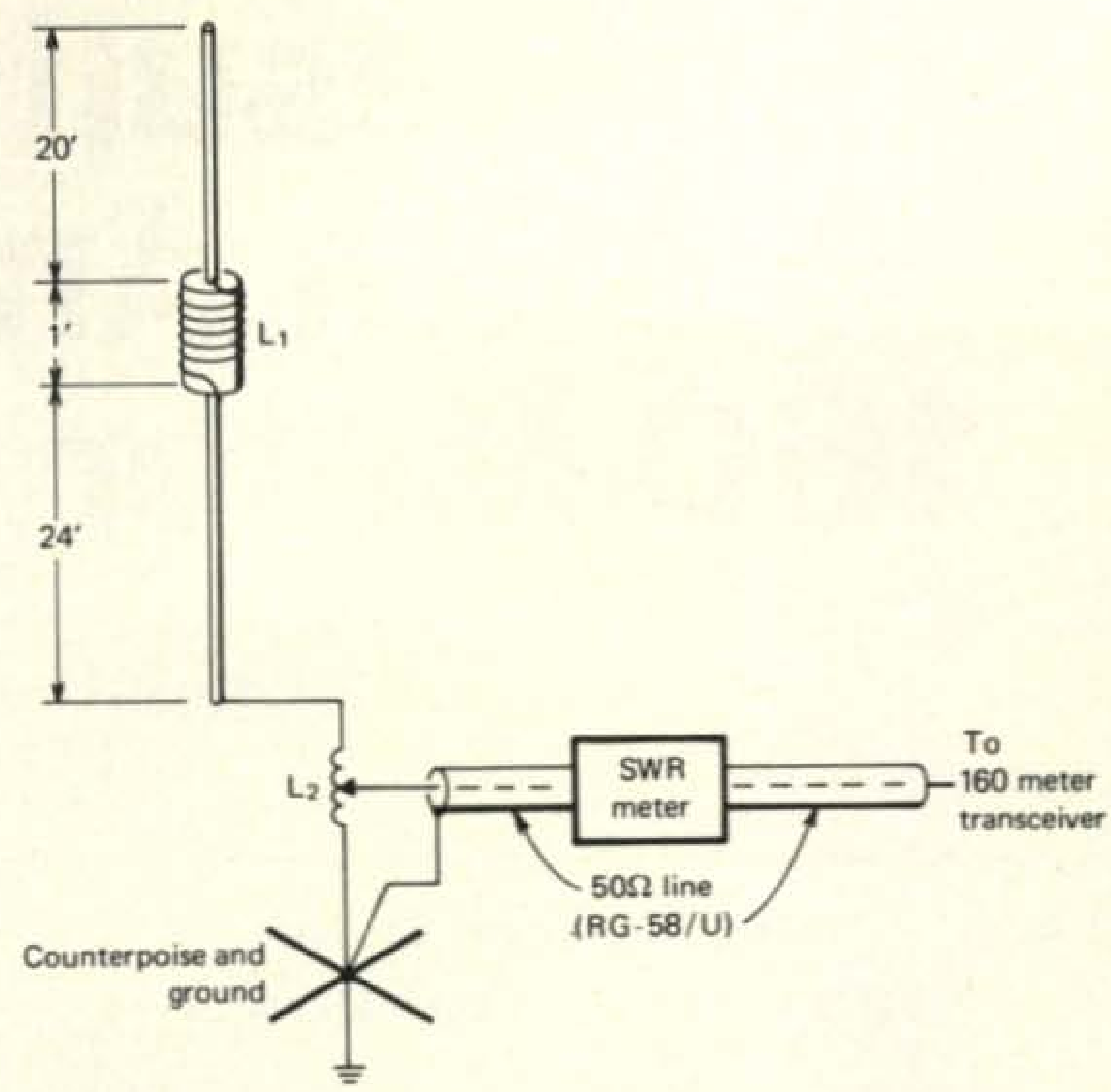


Fig. 5—Compact vertical antenna for 160 meters. The "whip" is made of sections of aluminum TV mast. Loading coil L_1 is 160 microhenries. It is wound on a form 3" diameter and one foot long. Plastic PVC pipe may be used, with the ends plugged with wood. The winding is 9" long and consists of 90 turns of #12 enamel coated wire. The ground connection consists of a water pipe ground, one or two ground rods and several 125 foot, insulated radial wires, run about a foot above the earth. The matching coil, L_2, is 20 turns #12 tinned wire spacewound, 1½" diameter, 2" long. Antenna bandwidth is quite narrow, so antenna should be dipped to preferred operating frequency in the band.

"What about the fellows that either don't have a tower, or want to use a separate vertical antenna for 160 meters?" asked my friend.

"Well, here's some information on a simple 160 meter vertical antenna that I have used for some time. It is only 45 feet high (fig. 5). The vertical section is made of aluminum TV mast sections bolted together. The loading coil is wound on a wood form, 3 inches in diameter and a foot long. The antenna is guyed just below the loading coil at the 24 foot level with three lengths of plastic clothesline. At the bottom of the antenna is a small matching coil which has a tap on it for the 50 ohm coaxial line."

"How do you adjust the antenna to frequency?" queried Pendergast, making a sketch of the antenna in his notebook.

[*Continued on page 78*]

Antennas *[from page 31]*

"The best way is to disconnect the coaxial line and couple a grid-dip meter to the base matching coil, L_2. The antenna and radial system should resonate to your operating frequency. If it does not, the length of the antenna above the coil, or the number of turns in the loading coil, L_1, are adjusted until resonance is accomplished. The operational bandwidth of the antenna is about 20 kHz between the 2-to-1 s.w.r. points, so it is essential that resonance at the desired frequency is achieved. For c.w. work, the antenna is resonated at 1810 kHz, and for s.s.b. it can be resonated about 1825 kHz. That's for the areas that have the low frequency portion of the band," I added as an afterthought.

"Once antenna resonance is established, the coaxial line is tapped on matching coil L_2 near the mid-point. The tap is adjusted up or down until the lowest s.w.r. is achieved. If it is not low enough, the total number of turns in L_2 may be changed, a turn at a time. This may sound like a time-consuming task, but it is not. The whole thing can be done in an hour, or less."

I paused and looked at Pendergast. "Before you run home and start winding a loading coil, there are a few things to be said about the radials and grounding system. While radials and ground connection do not look important on the antenna diagram, they are *very important* when it comes to antenna performance. This is especially so when a short antenna of this type is used. The radiation resistance of this antenna is about 4 ohms. You can't overcome the loss resistance in the two coils, but you can make them as low-loss as is possible. The last important source of loss over which you have any control is the ground loss. This is something that you can control, if you have the time and fortitude. And it will make the difference between a mediocre antenna and a good antenna."

Pendergast said nothing, so I continued. "The real earth ground about us is a poor imitation of an infinite copper ground screen. Measurements made by the Bureau of Standards established ground conductivity running from 340 ohms per cubic centimeter to as high as 450,000 ohms per cubic centimeter. Conductivity varies with the type of soil, temperature and the degree of moisture content in the soil. Ground resistance is the highest in cold, dry weather and the lowest in hot, humid weather. A gravelly, sandy soil, according to the Bureau of Standards *Technical Report 108*, has a resistivity so high it is practically a good insulator.

"The chief effect of high resistivity soil is to absorb the useful, low angle radiation from a vertical antenna. In addition, the ohmic loss of the soil eats up valuable r.f.

Pendergast thought a minute, then asked, "Does the ground rod show any resistance to the soil, that is, apart from the soil conductivity?"

"Well, according to studies footnoted in the Report, ground rod resistance to the soil can run several hundred ohms in extremely dry, rocky soil, but usually runs in the region of 2 to 20 ohms.

"It is practical to treat the soil in the vicinity of the ground rod by mixing it with salt(sodium chloride), about one part of salt (sodium chloride), about one part of rock salt will work—is mixed in to a depth of several feet and the mixture thoroughly watered. A ground rod at least 5 feet long is recommended, and two connected in parallel a few feet apart are even better.

"Since the salt eventually dissolves away, it is necessary to repeat the treatment at about six month intervals. If the ground current is monitored, it will be found to start dropping off when the salt leaches out of the soil".

Pendergast sighed and closed his notebook. "Isn't there an easier way of doing things than to run around salting the earth?"

"Yes, and now you are back to the use of quarter-wave radial wires, which act as an artificial ground system," I replied. "As to the number, two wires are better than one, and four are better than two. And so on. After sixty or so wires, the improvements starts to level off. Broadcast stations use 120 radials, laid out like the spokes of a wheel, every 3 degrees around the tower. Not many hams can do this, so they settle for three or four radials, run out haphazardly through the bushes and around the yard."

My friend rose and picked up his *Kamikaze 1000 transceiver*. "I think, for my location, I'll use the Marconi antenna made out of twin-lead," he stated. "I can put up three, quarter-wavelength radials . . . and that's it. I've run out of room."

"Good show," I answered. "I had a set-

up like that for several years. It enabled me to work all over the United States on c.w., and as far east as Tennessee on s.s.b. That's not bad for low power and such a simple antenna. I suggest you go ahead. You'll have a lot of fun with an antenna like that."

Pendergast walked toward the door. "I'm looking forward to 160 meters," he said. "I want to work Mr. one-sixty himself, W1BB."

"A coincidence," I replied. "I just got a letter from Stew and he asked when Pendergast was getting on 160 meters. You'll make him happy, I'm sure. It isn't every day when a fellow can QSO a straight-arrow like Pendergast".

Pendergast turned a little red at the remark, then said, "Are you still offering a freebie for good antenna dope?"

"Yes," I replied. "I am always on the lookout for good information on antennas that will be of general interest to the readers of my column. Interesting antenna experiences, in terms of operation; unusual antennas; comparisons between various antennas; and so forth. I would like to hear from fellows working DX on 80 and 160 meters as to the antennas they use. In fact, any antenna information of import will be interesting to the readers. So, for any material used in the column, I'll send a copy of one of my antenna handbooks". ■

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WILLIAM I. ORR, W6SAI, ON

Antennas

"Nothing enrages a vulture as much as biting into a glass eye," remarked Pendergast.

"Why do you say that?" I inquired.

Pendergast did not reply, but the copy of the *Appliance Operator* magazine he was reading was tossed into a graceful arc, landing in the waste basket.

"It is the end of DX," replied my friend in an angry voice. "Can you imagine making two pee-wee islands in Canada into two new 'countries'? It boggles the mind! What next?"

"This opens up a world of possibilities," I replied. "Think big. Why, all the National Parks in the U.S. can become separate 'countries'. Take Yellowstone Park, for instance. It's run by the National Park Service, has its own Police Force, and has a different color on the map than the surrounding states! It is a natural for a new 'country'. Or how about Treasure Island in San Francisco bay? It's under Navy jurisdiction, not the state of California. It has its own Fleet Post Office address and the autos on the island have Navy license plates, not California plates. And how about Manhattan island? If it were a new 'country' and the Manhattan hams charged a dollar a QSL card, they could bail New York city out of all its financial difficulties . . ."

"Stop!" commanded Pendergast, holding up his hand in mock protest. "I have my own private means of compensation. Goodbye to false 'countries' and hello to v.h.f. DX! I'm thinking of going up to 2 meters and I'm getting interested in moonbounce work!"

"Have you seen the latest issue of *CQ-Ham Radio* from Japan? It has a feature article on moonbounce communication and a lot of information on the 144 MHz contact between JA6DR and W6PO. And plenty of good pictures of moonbounce antennas and v.h.f. stations in JA-land."

My friend brightened up. "Well, maybe it isn't the end of DX after all. Just because the 20 meter DXers are fooling around doesn't mean that DX is really dead."

E-M-E path loss	Distance miles (kM)	50MHz (db)	144MHz (db)	432MHz (db)	1296MHz (db)	2400MHz (db)
Perigee	221,463 (356,334)	177.89	187.08	196.62	206.17	211.43
Apogee	252,710 (406,610)	179.03	188.21	197.76	207.21	212.56

Fig. 1—Free space path loss for earth-moon-earth circuit when the moon is at perigee (221,463 miles) and apogee (252,710 miles). The nominal 1.4 decibel difference in signal loss between perigee and apogee becomes 2.28 decibels for the round trip to the moon and back. For a marginal circuit, the additional loss may make the difference between success and failure. The chart is based upon a transmitter power output of one miliwatt.

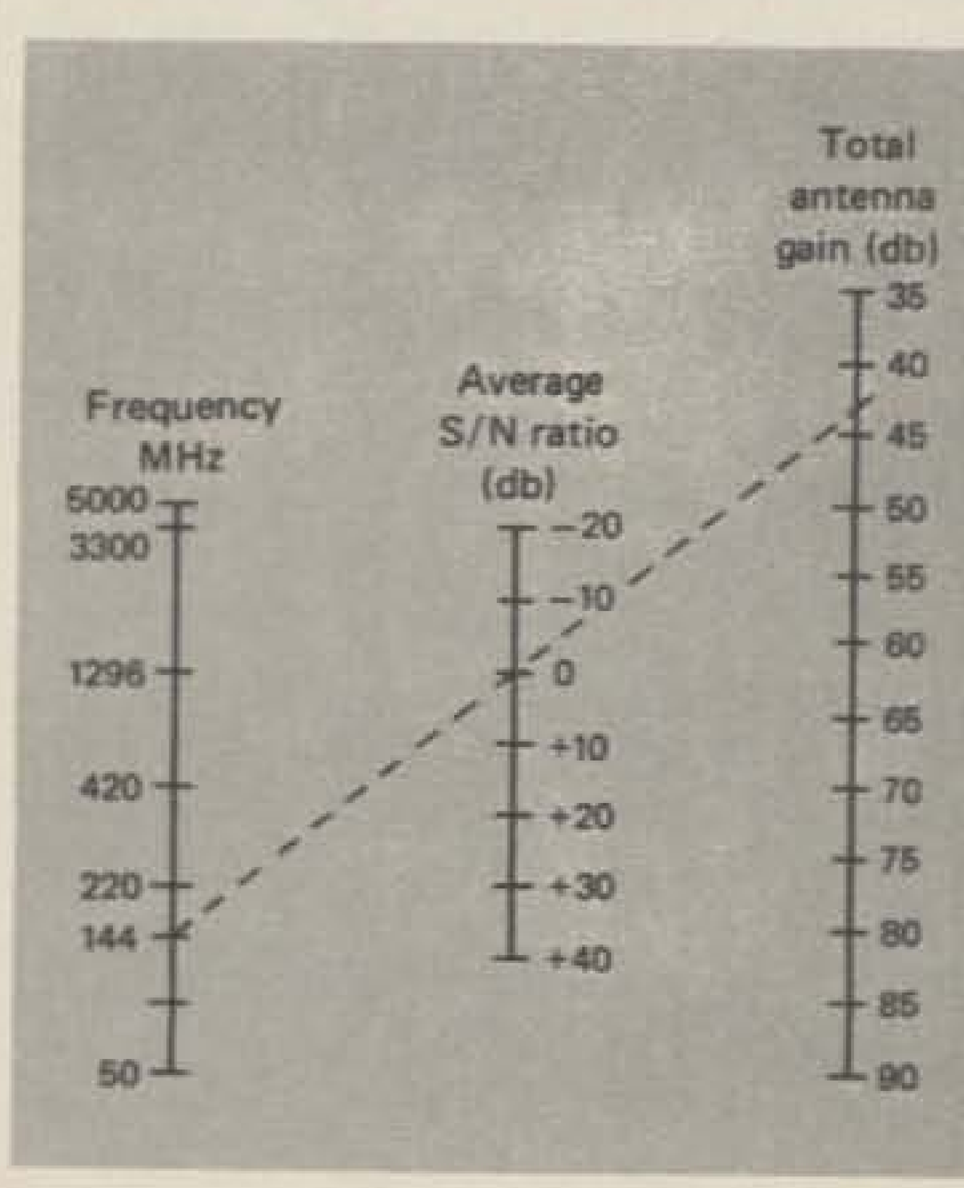
"Right," I exclaimed. "There's a lot of DX activity on 144 MHz, 220 MHz and 432 MHz. Take 2 meters. My friend W6PO is up to 33 states via moonbounce and meteor scatter, 4 continents, and has worked over 40 stations via moonbounce. And there are others who have higher totals than his."

Pendergast took out his black notebook, with a serious expression on his face. "Tell me all about it," he commanded. "Especially the antenna problem."

"The *first* problem to solve is which band to use," I said. "An error of choice at the beginning of the game could turn out to be very expensive and time consuming. As you know, radio signals traveling through space are attenuated as the square of the ratio of the frequency. Consequently, the path loss to the moon and back is 8.3 times (9 db) greater on 144 MHz than on 50 MHz, and a similar increase in path loss occurs between 144 MHz and 420 MHz and between 420 MHz and 1250 MHz. Figure 1 shows the loss, based upon 1 milliwatt of radiated power.

"In addition, transmitter efficiency tends to decrease and receiver noise

Fig. 2—Moonbounce nomograph provides guideline to successful EME contact. The graph is based upon 590 watts output, zero decibel receiver noise and 100 Hz bandwidth. Lay a straight edge across any two columns and read the desired unknown in the third column. The antenna gain figures represent a compromise between calculated gain required based upon free space losses and the experience of successful moon bounce experimenters. At 144 MHz, for example, for an average signal-to-noise ratio of two decibels, a total antenna gain (for both ends of the path) is about 44 decibels. The graph shows an example for a zero decibel signal-to-noise ratio, but this is impractical at 144 MHz because of sky temperature noise. The zero decibel figure, however, is quite practical at 432 MHz, where the sky noise is lower.



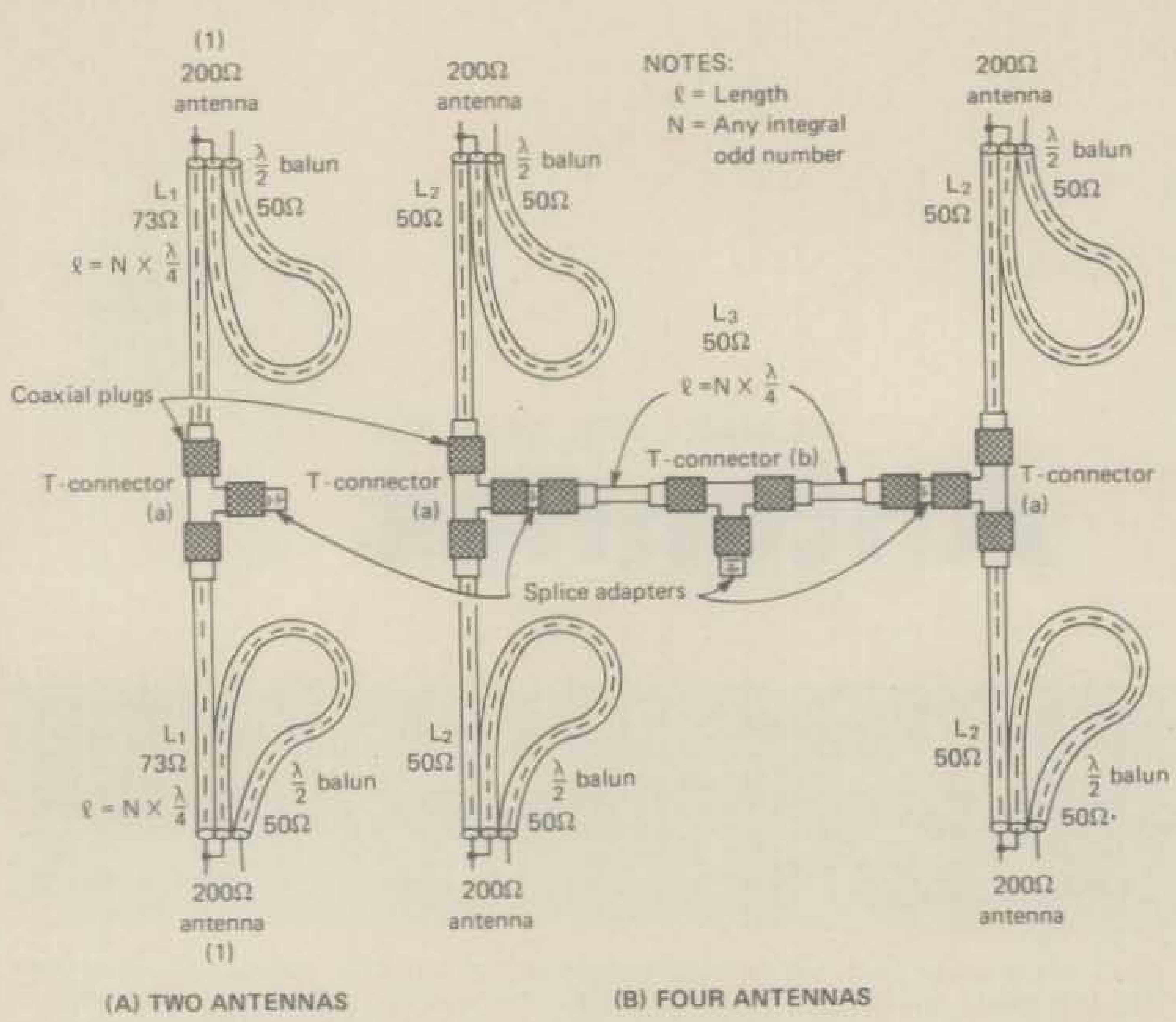


Fig. 3—A coaxial cable manifold feed system for two and four antennas. Each antenna is provided with a 200 ohm balanced feed point (a folded dipole, for example). A half-wavelength coaxial balun is placed at each antenna to convert the impedance down to 50 ohms. At the lower frequencies, the folded dipole and baln are often replaced by a gamma matching system. Individual dipoles are joined to the common 50 ohm transmission line by means of matching sections L1 and L3. Sections marked L2 are not considered as transformers as they match 50 ohm terminations at each end.

and transmission line loss increase with increasing frequency. So there are compelling reasons to use as low an operating frequency as necessary."

"It sounds as if 50 MHz is the band to use," muttered Pendergast.

"On the other hand," I continued, "the power gain of a directive antenna of a given size increases by the same ratio that the path loss increases and, because the antenna gain is realized in both transmission and reception at each end of the circuit, there is a net signal gain with increase in frequency, even after deducting the increased circuit path losses."

"Well, then, 420 MHz is the band to use," said Pendergast.

Which Band to Use for Moonbounce?

"I would think that at the present state of v.h.f. technology, the various gain and loss factors seem to combine most favorably on the 420 MHz band. Conventional tubes work well and you can generate the necessary power at this frequency. Good, low noise receivers are easy to make. In addition, conventional stacked, multi-element Yagi and collinear antennas of reasonable size are relatively easy to assemble and provide sufficient gain for successful EME (earth-moon-earth) communication. And there are operational 420 moonbounce stations in many parts of the world."

I took a big breath and continued. "The 220 MHz band is a difficult one because it is not an international assignment and it has a lot of QRM from channel 13 TV 'spill-over' in many areas. And a lot of fellows are reluctant to make the substantial investment in time and money if the band is going to be split up for the Citizens Radio Service."

"You sound as if 144 MHz may be *the* band for EME work," observed my friend.

"It is a personal opinion," I replied. "To date, most amateur moonbounce contacts have taken place on the 2 meter band. That's where the action seems to be, as of right now."

"How much power is needed? What about antenna gain?" asked Pendergast.

"Well, look at the chart of fig. 2," I replied. "The right-hand scale is total antenna gain for the EME circuit. The example shows that if a 144 MHz station at one end of a moonbounce circuit is equipped with an antenna having a gain of 26 db over a dipole, the station at the other end will need only a 17 db antenna to provide an average signal-to-noise ratio of zero db. This graph is based upon a transmitter power output of 590 watts, zero db receiver noise figure and 100 Hz receiver bandwidth."

"And two stations using 22 db beam antennas can do the job," said Pendergast.

"This is the average situation," I replied. "Don't forget that at 220 MHz and below, sky temperature changes make a zero db noise figure impractical. About the best you can achieve is 2 db noise figure. Anything much better than that will just 'hear' more noise."

"Any other problems?" asked Pendergast.

"The free space path loss varies about 2.28 db on the round trip, because the orbit of the moon is not a perfect circle, the distance to the moon varying between 221,463 miles and 252,710 miles. And you also have to take Faraday Rotation and Doppler Shift into account."

Faraday Rotation and Doppler Shift

"This sounds more complicated than 20 meters," groaned Pendergast. "What are these problems? What do they mean to the newcomer on EME?"

"Take Faraday rotation. When a radio signal travels to the moon, it may be rotated in polarization several times before it strikes the moon. When the signal is reflected back to the earth, any rotation present is enhanced on the return journey. Faraday rotation is produced by the effects of the earth's magnetic field and the resulting polarization change produces a cyclic fade in the moon-reflected signal because the path length is continually changing. On 144 Mhz the fade is quite slow, and most moonbouncers merely work around it.

"Doppler shift is the change in frequency of the received signal due to the relative motions of the moon and the earth. At the equator, the shift in Hertz is 2.966 times the frequency in MegaHertz. When the moon is rising, the received frequency is increased; when it is setting, the frequency is decreased."

"Wow," said Pendergast, shaking his head in amazement. "It sounds as if moonbounce communication is really pushing the state-of-the-art, as far as amateur radio is concerned."

"That's right," I agreed. "The moon only reflects 7 percent of the signal that strikes it, and that portion of the

signal is re-radiated and diffused all over space. The fraction of the echo signal that returns to earth is spread over an area of about 98,470,000 square miles. Compare this vast area to that of even the largest 144 MHz antenna! Obviously only a small fraction of the transmitted power ever reaches the receiving antenna after the round trip to the moon. Yet, amateurs are having QSO's regularly by moon reflected signals on both sideband and c.w. So you see why moonbounce has challenged the best talents of many of the world's most skilled v.h.f. amateurs. No wonder they don't get excited when a new 'country' is invented by over-eager DXers!"

Active Moonbounce Antennas

"Leaving aside the problems of locating and tracking the moon, let's look at the moonbounce antenna for 144 MHz. The *ante* to get into EME is an antenna, steerable in both azimuth and elevation, that provides about 20 db gain over a dipole. Practical moonbounce antennas often consist of an array of beam antennas. Stacking two or more antennas to obtain additional power gain or directivity requires that each antenna in the array be fed an equal amount of power in the proper phase. The power to the array, therefore, must be divided evenly between the antennas. The secret of success is the use of a completely symmetrical feed system which applies power to the driven element of each array in equal fashion. A *manifold feed system,* such as shown in fig. 3 is one way of doing the job. This illustrates the method of feeding two, or four, Yagi antennas from a single coaxial line. The driven element of each Yagi has a balun and matching device so the antenna presents a 50 ohm termination. Typically, this may be done with a folded dipole driven element having the proper impedance transformation, and a half-wavelength balun. There are several other ways of accomplishing this, including the gamma match, and the omega match."

I paused as Pendergast continued to write in his notebook. "The individual dipoles are then joined to the main transmission line via quarter-wavelength matching transformers. In fig. 3A each dipole and balun combination is adjusted to 50 ohms at point (1) and the impedance is then stepped up to 112 ohms by virtue of the 75 ohm coaxial transformer section. At point (a) the two 112 ohm terminals are placed in parallel to provide a nominal impedance of about 56 ohms, which closely matches the impedance of the main transmission line. Adjustments are made by monitoring the s.w.r. in the main line.

"Figure 3B shows how four antennas may be matched and fed with a 50 ohm line. Again, each driven element is a folded dipole having a 200 ohm termination that is transformed to 50 ohms with the aid of a half-wave coaxial balun. The remainder of the harness is made up of 50 ohm coaxial line. The section designated as L2 is not considered as a transformer and the length is unimportant, as long as all L2 sections have equal length. At points (a) on each side of the harness, the two sections are connected in parallel to provide a nominal impedance of 25 ohms. Sections L3 are 50 ohm transformer sections which provide a step-up transformation to 100 ohms in each instance. Parallel the two terminals at point (b) to provide a nominal 50 ohm terminal to match the transmission line."

"How do you mount such a monster in the air?" asked my friend, as he looked at the illustration.

"Obviously you need a very rugged framework to keep all that antenna and harness in the air. Figure 4 shows you the general idea. This frame is designed to support four long 144 MHz Yagi beam antennas. The cross-bracing is important to counteract wind forces.

"Some amateurs having even larger arrays than this use tower sections for the horizontal portion of the boom structure. Some very impressive designs are shown in the photographs."

"Well, how many individual antennas do you need to get the job done?" demanded Pendergast. "It looks to me that it's almost an impossible task."

"It is possible to make a good estimate," I replied. "One of the most popular arrays is made up of 8 Yagi beams, stacked four over four, as shown in fig. 5. A widely-used Yagi is the 7-element job shown in the *ARRL VHF Manual.* A conservative estimate of gain for this antenna is 11 db. Two antennas, properly stacked one above the other should give you twice the field strength, or

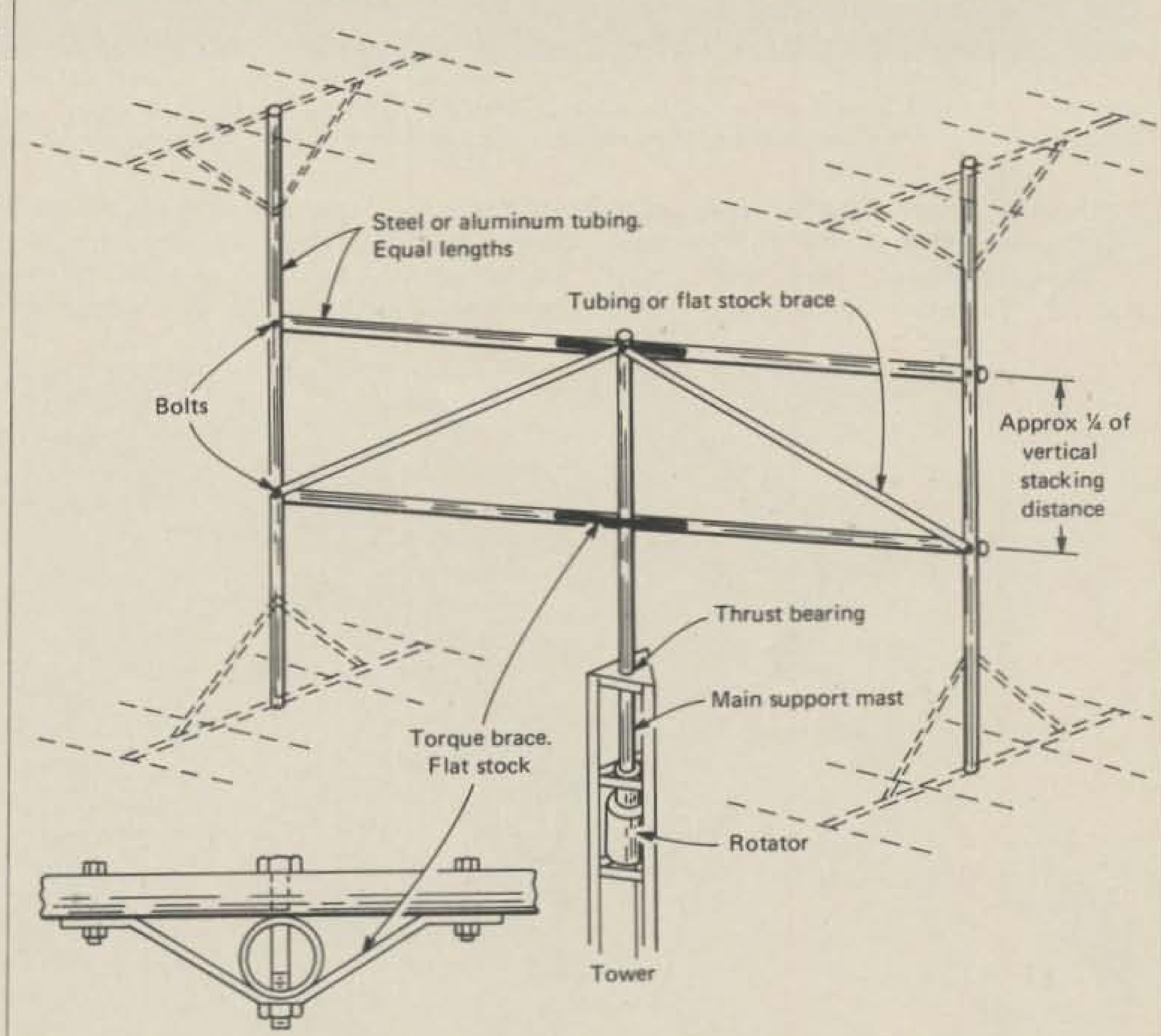


Fig. 4—Representative stacking framework to support four long Yagi antennas. The cross-bracing is important to counteract wind forces. Lateral stresses on the framework are a function of the frontal area facing the wind and its distance from the support mast. The same style of assembly can be used for vertically polarized arrays but the framework members in the same plane as the elements should be made of nonconducting material. The stacking distance is a function of the capture areas of the individual antennas and increases with the gain of each antenna. Stacking distance must be carefully chosen if maximum front-to-back and minimum side lobes are desired. Rule-of-thumb indicates a stacking distance equal to boom length of one antenna.

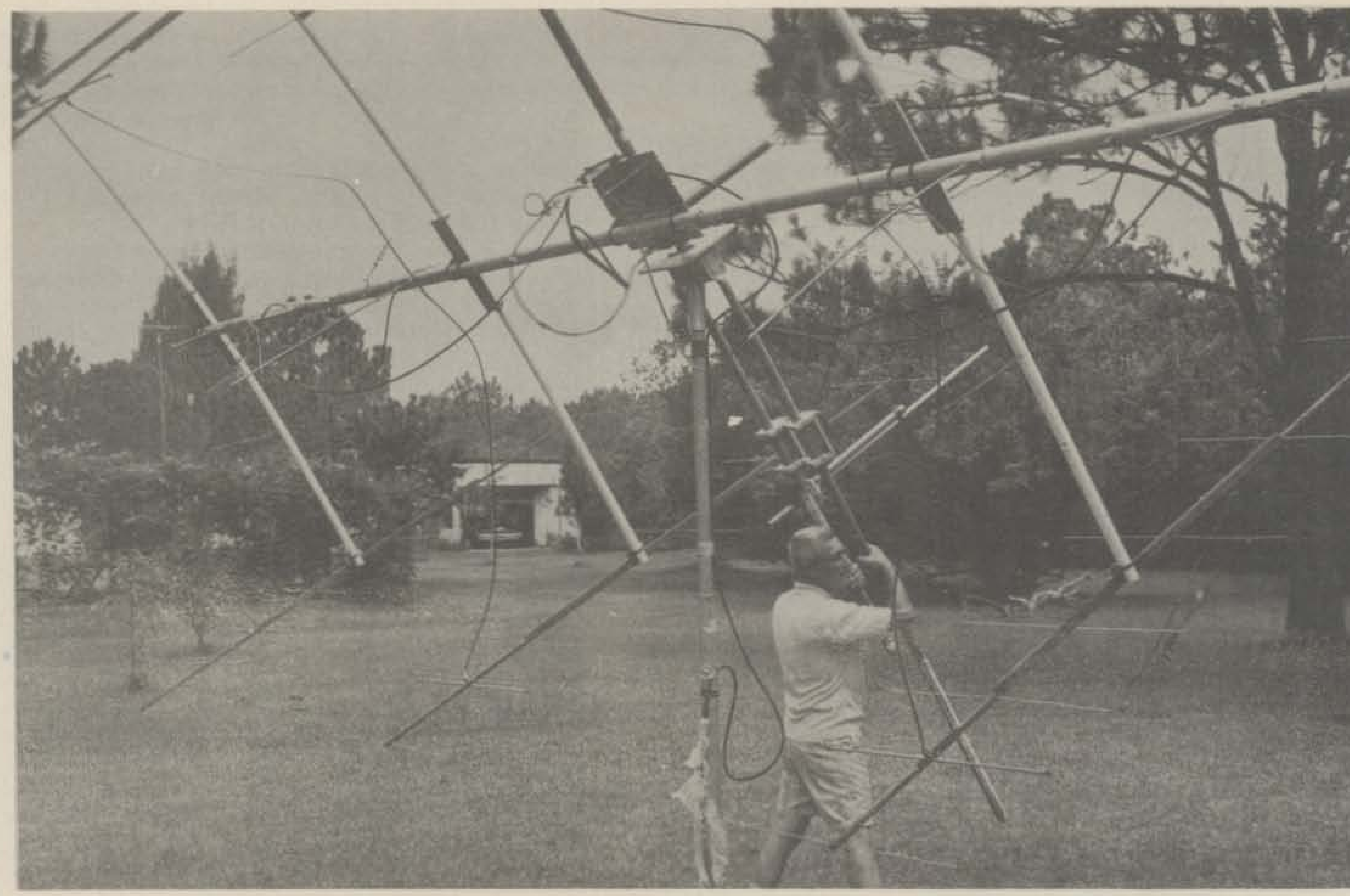


Fig. 5—The "four over four" array of K4IXC. John's antenna is made up of eight, 7-element Yagis. The assembly is low enough for easy aiming and maintenance. The antennas are fed with a coaxial harness. John's final amplifier uses a pair of 4CX250B tubes.

3 db more power. So that adds up to 14 db over a dipole. An arrangement of four antennas (two over two) should provide twice the field strength, or a power gain of 17 db. Now, if you double the size, to include eight Yagis (four over four) you add another 3 db, to achieve a power gain of 20 db."

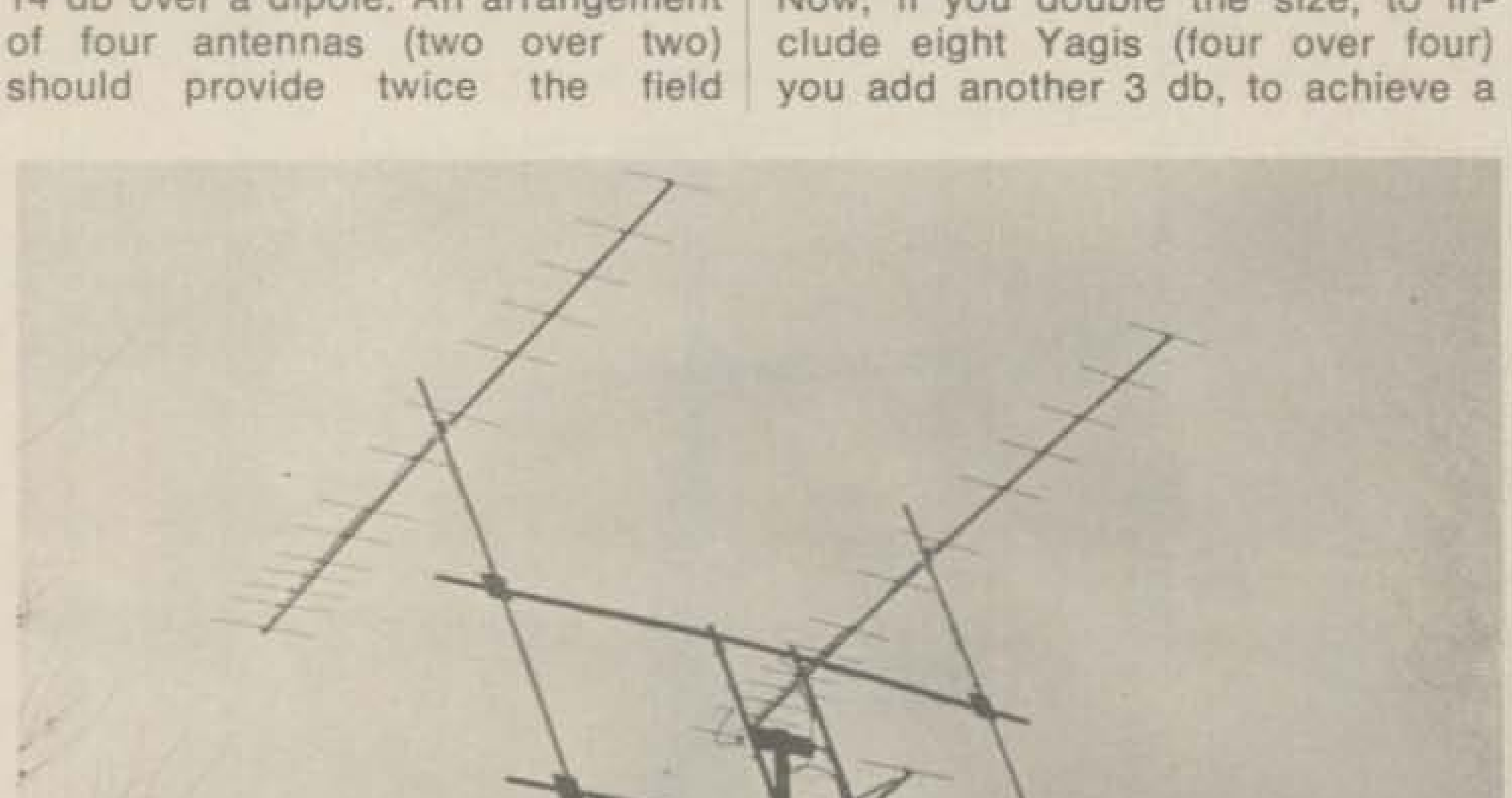


Fig. 6—Orville, K5VWW did an excellent job on this array of four 14-element, 144 MHz KLM log-periodic Yagis to provide an easy way to change the elevation of an "H-frame" mounted array. Both K4IXC and K5VWW are prominent "moonbouncers."

"That's barely enough," objected Pendergast. "You were speaking of a power gain of about 20 db, *or better.*"

"Right," I agreed "But this antenna will work for EME, even though it might be considered marginal. Other experimenters have antennas that have more than average 20 db power gain, and make up the difference. K4IXC, one of the more popular moonbouncers, uses an antenna of this type and has made many contacts. In order to actually achieve an overall power gain of 20 db, you have to use eight Yagis at minimum, each with a power gain of 11 db, or better. And I'm not talking about inflated, DX-type decibels! These are the *real thing*. Of course, the problem is that as the gain of the individual antenna is increased, the spacing between the antennas in an array must be increased too, or full power gain will not be achieved. Each antenna has an *effective aperture*, or zone about it, that must not be invaded by the adjacent antennas. By spacing the individual beam antennas so their effective apertures just 'touch', power gain will increase

(Continued on page 74)

Antennas *(from page 48)*

directly as the number of antennas is used. And a rough approximation of the aperture is the boom length of the antenna itself."

"So as the individual beam antenna grows longer to achieve more gain, the effective aperture increases and more stacking distance is required," mused Pendergast, as he contemplated the photographs.

"That's right," I replied. "There's no free lunch, and the bigger the antenna, the greater the difficulty in supporting it and in making a rugged array that is still light enough to be supported in the air by a reasonable framework."

Pendergast sighed. "It all sounds fascinating and a real challenge. I would like to learn more about moonbounce. It seems as if it is one of the last resorts of the true, amateur experimenter."

"The v.h.f. region is where the real action is, contrary to what you might hear on the DX bands," I replied. "But you have only scratched the surface. When you have a few more moments, we'll go into moonbounce a little deeper.

"Don't forget, I am still looking for photographs and descriptions of interesting antenna installations, high frequency, or v.h.f., it matters not, and I'll send one of my antenna handbooks in response to any such material that I use in this column."

"Right," said Pendergast as he got ready to leave. "And may you prosper in 1976."

"The same to you," I replied. "That's very Centennial of you and I appreciate your good wishes." ■

QRP Challenge *(from page 44)*

time, if the time was given in hours of operation time, and days of listening for hours without hearing a needed country, it would not sound too short.

There was only one problem now. It's true that I had worked the hundred, but I was still short 65 QSL cards to qualify for the trophy. To make my waiting for the cards almost unbearable, it took me over two months to go from 99 to 100 confirmed. Finally, just a few days short of one year from the time I worked my 100th country, a shipment came from the W2 QSL bureau containing four new ones bringing me up to 103 confirmed (I had 119 worked at this time, including all continents on s.s.b. phone). I would like to thank Adrian Weiss for his dedication to QRPp and his sponsorship of the fine QRPp awards program, the YL ISSB for their friendliness and help. My DX associates who occasionally allowed me to ride "piggyback" on a DX contact, and last but not least the Ten Tec Company for designing the oustanding little Argonaut.

If any of you are contemplating QRPp operation be prepared for one thing—to have the time of your hamlife.—*W2GRR*

The big question is: who will be next, and how long till he claims DXCC QRPp #3? An even more tantalizing question is: will anyone ever qualify for *DXCC MILLIWATT?* Several of us have passed the 100 countries-worked mark with five watts, but those cards are ever so slow in coming. Sandy resorted to all known tricks short of transoceanic telephone calls—but that is a story in itself. We'll be waiting for the next qualifier nonetheless. W2-GRR's achievement is considered sufficiently noteworthy by *CQ* so as to warrant the coverage we're giving it! And plans are in the works for a separate QRPp section in the annual *CQ* WW DX Test coming up later this year. QRPp is where a real challenge is in ham radio—give it a try if you have a taste for competition! 73, Ade, K8EEG

160 Meter Amplifier *(from page 27)*

raised the proper amount. When switched in, the transmitter (with decreased drive to the final) puts out about 5-6 watts. Power output with full drive at 13.6 Vcc is 13.2 watts; at 12 Vcc about 12.5 watts, and about 9.5 watts with 11 Vcc.

The circuit of the "L" network antenna coupler is shown along with the final amplifier circuit in fig. 2. Two Amidon T-68-2 toroid cores are wound full circumference (53 turns) with #24. The first tap position connects the output link L_4 directly to the coax output receptacle, and the remaining ten tap positions allow insertion of up to about 24 μh in roughly even steps for the first six taps, and larger amounts for the remaining steps. A two terminal strip used in the original amplifier was on the rear panel, and pressed into service as a junction point for adding external capacitance to C_4.

Results

The new final amplifier has really improved the performance of the transmitter in terms of stability, ease of tuning, and efficiency of operation. Contacts have been made throughout the U.S. using a 60 foot top-loaded vertical with a very inefficient ground system (ever try burying radials in frozen dirt?). I'm sure that this rig will provide much satisfaction for a long time to come. While I didn't end my earlier paper with any exhortations or promises of ease of construction and operation, I am inclined to put thet full stamp of approval on the entire rig now that the new final amplifier is in operation. 13 watts will go a long way on 160 meters with a decent antenna. And the application of the new balanced emitter 2N5590 has removed any difficulties that were present in the original transmitter. ■

Radiant Photons *(from page 34)*

inated surface. This instrument is essentially a photo-diode and a calibrated micro-ammeter. Another useful relationship is, $F = E \times A$. Here, F is the flux or power which resides in the light impinging upon a surface of area, "A". Additional concepts appear "post-script" fashion in fig. 8.

You should now be in a more favorable position to acquire skill in working out light problems, but as the textbooks often state, "that is left as an exercise for the student." Good luck, OM, and remember that in an opto-coupler you can express the input and output in *electrical* quantities without concern over the radiation path in the middle of the gadget! ■

WILLIAM I. ORR, W6SAI, ON

Antennas

Pendergast looked out of the shack window and sighed. The rain was coming down in torrents and drumming against the glass. The yard was full of puddles of water and a miniature river ran down the walk to the gutter, which was bubbling over with sticks and dead leaves jammed against the drain. The guy wires on my tower hummed in protest to the gusty wind blasts. Looking up, I observed that the sky was a cold, gray color with lowering clouds scudding swiftly across the horizon.

My friend sighed. "This isn't a very good day to think about antenna projects", he said. "Now, if you only had a warm fireplace in this shack, we could have a conversation about antennas in the proper atmosphere. That would be great! Sit around the fire, with a tall, cool one in your hand and discuss DX and other good things". He pulled down the window shade so that we could no longer see the advancing storm. Its presence was still felt, however, as the shack trembled a bit under the wind blasts and an icy scimitar of air slashed in around the window cracks.

"I've been catching up on my reading", I remarked. "Do you ever read *Broadcast Engineering*? No? A fine magazine. In the November, 1975, issue there is a very interesting article on detuning skirts for tall towers that radio amateurs would do well to consider.

"The article considers the case of a broadcast station which used one tower for both a.m. and f.m. transmission. The f.m. array was placed at the top of the tower which was 490 feet high. This was of great advantage for extended f.m. coverage, but the height screwed up the use of the tower for general a.m. broadcast use, since the electrical height at the operating frequency was about 0.74 wavelength. This meant . . ."

"This meant that they had a lot of high angle, useless radiation since

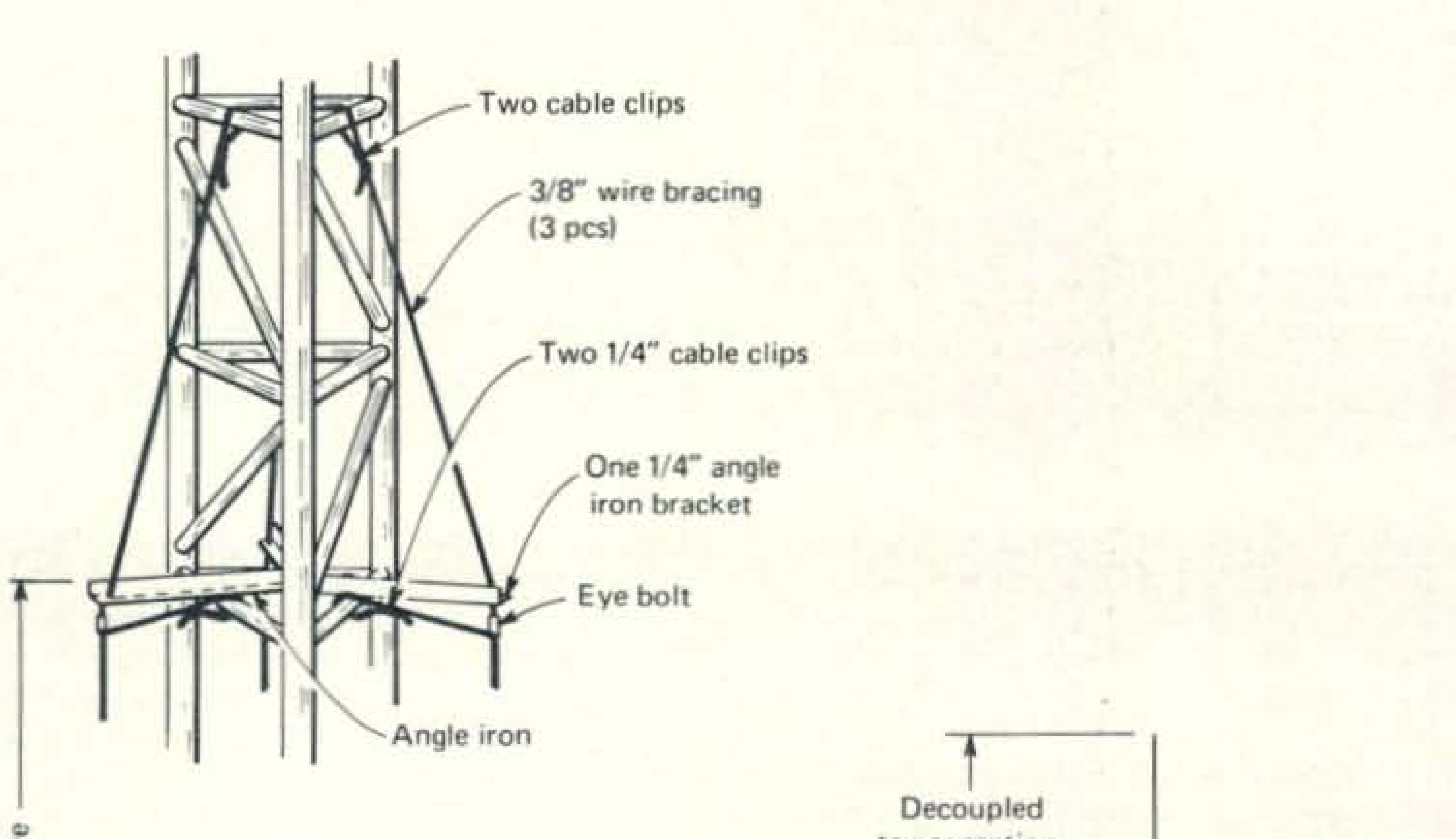
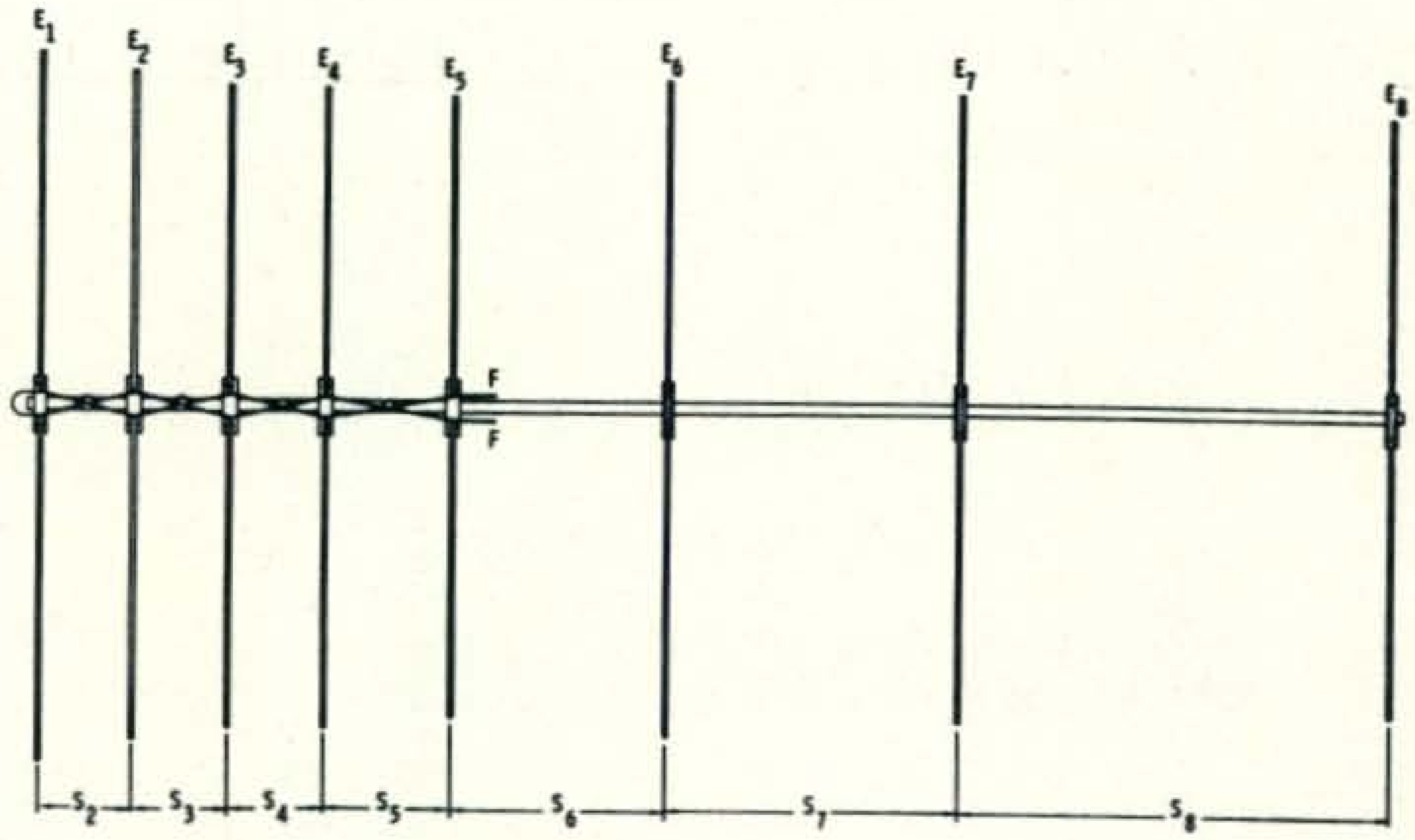


Fig. 1—The detuning sleeve for a broadcast antenna tower. The sleeve is a quarter-wavelength long at the operating frequency and isolates the top section of the tower. Made up of three conductors, the sleeve is grounded to the tower at the top end by the angle iron brackets. The bottom end of the sleeve is shorted to a circular metal support ring and braced to the tower with insulators, turnbuckles and cables. The center of the sleeve is strengthened by plastic pipe insulators extending out from the sides of the tower. The electrical equivalent is shown at the right.



L-P YAGI DIMENSIONS (TIP-TO-TIP)

ELEMENTS	1	2	3	4	5	6	7	8
INCHES	116.5	110	106	104	102	108	103	100
cm	296	279	269	264	259	274	261	254

SPACING	1	2	3	4	5	6	7	8
INCHES	-	15.5	15.7	15.7	20	35	49	71.5
cm	-	39.4	40	40	51.1	88.3	124.5	181.6

Fig. 2—The Log-periodic beam antenna for 50 MHz. This beam provides about 12 decibels power gain over a dipole and is mounted on a 18½ foot long boom. The L-P elements are insulated from the boom by mounting on insulated blocks. Yagi elements are grounded to the boom at their center point. The antenna is fed with a balanced 70 ohm ribbon line at feedpoint F-F. The L-P transposed transmission line is made of No. 8 aluminum clothesline wire, criss-cross connected between the element centers. The rear element is shorted with a six-inch loop of aluminum wire. The spacing between the inner tips of the L-P elements is 3½ inches. Elements are made of ⅜-inch diameter aluminum tubing tip sections, with ⅝-inch inner sections. (Drawing courtesy of "Radio Handbook", 20th edition, Editors and Engineers Division, Howard W. Sams, Inc.).

maximum horizontal field intensity is achieved with a vertical antenna of 0.625 wavelength, or ⅝-wave, as commonly expressed", interrupted my friend.

"Exactly right!", I replied. "Since broadcasters are interested in maximum groundwave radiation, as are amateurs on lower bands, the tower was too high. So the problem was, what to do? Cut the extra length off the top of the tower and degrade the f.m. coverage?"

Pendergast said nothing, so I continued. "The solution decided upon was to isolate a portion of the tower electrically, or detune it, if you prefer. This was done with a detuning skirt, such as shown in fig. 1. And there's no reason why such a gadget can't be applied to an amateur tower, if the user wants to use an existing tower as a vertical antenna.

"The technique is to add a quarter-wavelength detuning sleeve to the tower, isolating the unwanted section. The sleeve used for the broadcast tower is made of a wire "skirt" suspended from brackets. The skirt is grounded to the tower at the top end and insulated at the bottom end. This arrangement isolates all the tower above the skirt. The bottom of the skirt is interconnected to a metal support ring to make certain each wire of the skirt had an equal r.f. voltage potential on it.

"The skirt is made 0.234 wavelength long, since by underestimating the length, it could always be resonated with a capacitor at the bottom end. But, because of other effects, such as tower diameter and adjacent hardware, the length turned out exactly right. The remote field strength of the a.m. signal at the ground was boosted 3 decibels by the addition of the skirt".

"That's not a bad idea", admitted Pendergast. "Particularly for those amateurs who have a tall tower, top loaded by a beam, and want to work the tower as a 40 meter vertical, for example".

"Of course, control wires and the like, should run through the skirt, adjacent to the tower so that they do not detune it" I added.

Pendergast sketched the detuning skirt in his notebook, raised the shade to note that it was still raining, then said, "I have a request from a buddy for some information on the LPY (log-periodic Yagi) beam antenna for 6 meters. Got any information in your file?"

"Yes", I answered. "I show just such an antenna in the new 20th edition of the *Radio Handbook,* which just came off the press. Here's a quick run-down and sketch of it for your friend (fig. 2).

"This antenna consists of a log-periodic section, plus a number of parasitic directors. The log-section consists of a series of dipoles, fed at the center in such a way that adjacent dipoles are out of phase. The array is fed at the apex. Dipole lengths are adjusted across the band of frequencies in use and a broadband structure is formed. The bandwidth of the device is limited by the length of the longest and shortest elements, which must be about a half-wavelength long at the extreme frequency limits of the antenna.

"The LPY antenna is composed of a five element log-periodic section designed to cover 50 MHz to 52 MHz and is used in conjunction with three parasitic director elements mounted in front of the log-periodic structure. The antenna exhibits about 12 decibels power gain over a dipole and compares nearly identically with an 8-element Yagi mounted on a 30 foot long boom. The overall length of the LPY beam, on the other hand, is only about 18½ feet. Best of all, the LPY antenna provides superior bandwidth performance, as compared to the Yagi".

"How about the feed system?", asked Pendergast, sketching the antenna in his notebook.

"Notice that the rear element of the periodic structure is shorted with a wire loop across the line. This reduces reactance at the feedpoint, and the beam is fed with a balanced 75 ohm "ribbon" line. An antenna tuner can be used at the station to convert from balanced line to a coaxial feed system."

Pendergast smiled. "It sounds as if this antenna is a block-buster for six meters".

"It is", I replied. "And it also provides rejection against a nearby channel 2 TV transmitter, since antenna response drops quickly outside of the passband. That's great comfort in areas where channel 2 competes with weak 50 MHz DX signals in the front end of your receiver".

"How about coaxial feed?", asked Pendergast. "That would be nice".

"You can do it", I replied," with a balun placed at the antenna. But

don't forget: coaxial line losses start to mount, even at 50 MHz".

"I am a great believer in coax", stated my friend as he peeked out of the window again. "Not to change the subject, but I note your coaxial line to the tower is underwater now. Won't that damage the cable? Is it waterproof?"

"No and yes", I answered. "I use good cable, and the ends are sealed to prevent moisture from getting into the line". I handed Pendergast a small pamphlet. "Look throught this engineering information I compiled from brochures distributed by *Amphenol* and *Times Wire and Cable* which discuss coaxial cables. Here's some good and very timely information.

"And now that spring is on the way, the next few months will be a good time to maintain and overhaul your antenna installation.

"With the big rise in CB popularity, there's more and more coaxial cable on the market, some of it at attractive prices. But you have to watch out, because some of it is junk".

"I thought all coaxial lines were built to military classifications", objected Pendergast.

"Some of them are", I replied. "But there are important differences in the types of cable you can buy now. For instance, let's talk about the insulating jacket of the cable for a moment.

"The original, outer jacket used on the older cables, such as RG-8/U and RG-58/U, was made with a plasticizer compound that kept the jacket flexible and prevented it from cracking or crazing. It was found, however, that after a period of time the plasticizer would migrate from the jacket, through the outer braid and into the polyethylene insulating material around the inner conductor. This caused a chemical change in the insulation which increased the electrical loss of the material with time. As a result, the military established a useful life period for these cables, at the end of which they were either junked, or dumped on the surplus market."

"How do you tell if the coaxial cable is contaminated?" asked Pendergast, looking uneasily at a roll of coax in the corner of the room, as if it were a serpent, ready to strike.

"If the cable is really old, the inner insulation will have a yellowish, tint to it", I replied. "In addition, the outer copper braid will be badly tarnished. The cable loss, too, can be readily measured, especially at the higher frequencies".

I continued. "Newer coaxial line has an improved outer jacket which has a long life and is noncontaminating. Estimated useful life of these new cables is 20 years, or greater. Examples of these cables are RG-8A/U and RG-213/U. These cables are almost the same, the 8A having an impedance of 52 ohms and the 213 having an impedance of 50 ohms. Also, RG-58C/U replaces RG-58/U."

"Well", said Pendergast, "I still see a lot of new RG-8/U cable for sale in electronics stores. Is it old stuff, or new cable with the older jacket?"

"Hard to tell", I replied. "RG-8/U is no longer a military approved, MIL-SPEC cable, so it can be anything. For instance, an easy way to reduce the cost of coaxial cable is to reduce the amount of copper in the braid. Some new RG-8 cables have been cheapened to such an extent that if you bend the stuff, the braid spreads, leaving holes in it through which you can see the center insulating material. This is bad, as it allows r.f. leakage at the higher frequencies. This junk costs as much as better cable, but the profit to the manufacturer is higher. RG-213/U and RG-8A/U cables, for example, always have 7 strands in the inner conductor and the weave of the braid is very tight."

"How about the so-called "RG-8/U" *type* cable?", asked Pendergast.

"Well, you have to watch out for RG-8/U cable and also RG-8/U *type* cable. Since the MIL-SPEC control no longer applies, the cable can be altered, or modified, at the desire of the manufacturer. The shielding no longer has to be woven tight and the polyethylene inner dielectric is often omitted in favor of a foamed dielectric. The foamed stuff, in itself is not bad, but unless the foamed material is gas filled, moisture will ooze through the jacket and braid and into the foam. And, as you know, losses go up rapidly when moisture enters the inner dielectric of the cable".

"The moral, then, is to use MIL-SPEC RG-8A/U, RG-213/U or RG-58C/U cables", exclaimed my friend. In the long run, they are cheaper than some of the non-standard brands!"

"That's right", I replied. "The cost of a good coaxial line is a small part of the cost of a modern installation. Why be penny-wise and pound-foolish?"

Pendergast smiled as he said, "I shudder to think of all the junk coax I have bought over the years. Maybe that's why I am low man on the totem pole in a DX contest!" He changed the subject abruptly, as if to banish the thought from his mind. "Anything interesting in today's mail?"

"Well, I received a nice note from Gary, WA2UGO. He mentioned that he has used a quick-and-dirty antenna for 160 meter operation and recommends it to the readers of this column. Here's what he has to say. 'My main antenna is an inverted V dipole at about 50 feet. However, I've used a much smaller antenna on occasion with good results. It is a common multiband vertical antenna for 10 thru 80 meters, with 8 radials for those bands. For 160 meter operation, I just clip a wire onto the top of the vertical to make overall length about a quarter-wave at 160 meters (fig. 3). My wire runs horizontally from the top of the vertical to a tree, then zig-zags through the tree and to a second one, until all the length is used up. I suggest using a step ladder to attach the wire, as standing on my XYL's shoulders really got her mad'."

"Is this for real?" asked Pendergast, arching his eyebrows.

"I gues so", I replied. "All except about standing on his XYL".

"A clip-on wire is a good idea", admitted my friend. "This could apply to any multiband vertical. If you have a triband job for 20, 15 and 10 meters, you can clip on extra wire at the top for 40, 80 or 160 meter work. The overall length of vertical plus wire is about a quarter wavelength, but you can zero-in on it exactly, if you wish, by coupling

(Continued on page 72)

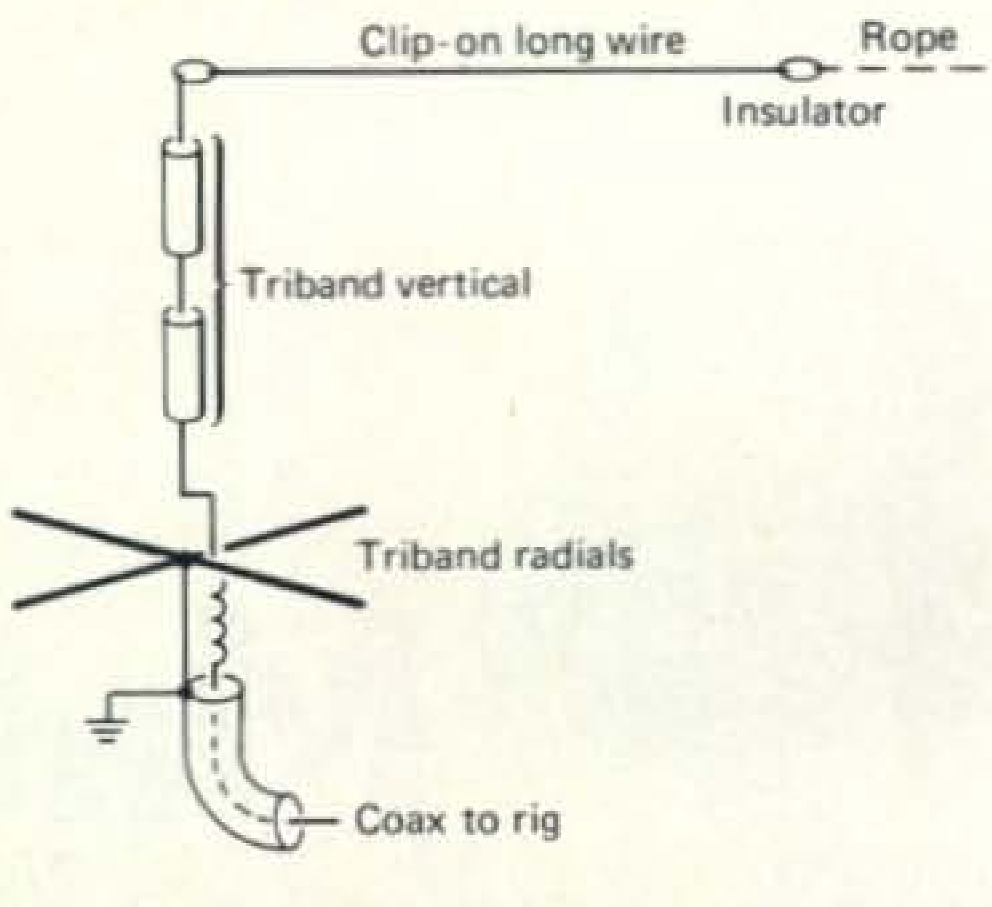


Fig. 3—The 160 meter clip-on antenna of WA2UGO. A triband vertical antenna for 10-15 and 20 meters is the basic antenna. Sufficient wire to make up a quarter wavelength (about 100 feet for 160 meters) is clipped to the top of the vertical antenna for top-band operation. The scheme will work for 80 meters, too, with about 50 feet of wire. The whole antenna can be resonated to frequency with the aid of a dip meter.

tone call from the car, or portable through the normal repeater system. A decoder is activated at the repeater by the 911 number, and connects to a special ring down line that terminates at one of the positions on a phone company call director in front of the dispatcher at the Cook County Communications Center. The dispatcher seeing the button flash, picks up the line and announces, "Cook County Sheriff's Police." The Amateur then gives his call, his repeater affiliation, his location, and the nature of the emergency. In most cases, the amateur would then disconnect by sending a # and 0 on his pad. In those cases where additional information is needed the connection can be held under the control of the Amateur. The Cook County dispatcher will handle all emergency calls for the six northern counties of Illinois.

This system has been approved by six repeaters so far, and at least two have the package working for their membership.

Properly used, this 911 in use by Amateurs can provide a great public service, and once again prove to the government, and the public in general, the advantage of Amateur Radio to the community. ■

Improving the HW-101 [*from page 44*]

ing loose or developing a poor connection between the ground foil and the chassis frame. Re-tightening the screws that hold the boards to the chassis should suffice, but for a more permanent solution, adding a few #4 flat solder lugs held by the nuts and washers used to hold the boards and soldering them to the board's ground foil at various points, will insure a better ground.

S-Meter Readings

As stated before, the i.f. gain of the set is quite high, tending to make the S-meter readings a bit too generous (even after replacing the 6HS6 with 6AU6). Also, during reception of very strong signals there may be some distortion due to product detector overload. The above can be corrected by soldering a small (¼ watt will suffice) 10 K resistor across the primary winding of the last i.f. transformer T_{103}. This will bring the S-9 reading to correspond to about 50 microvolts and the value of each S unit to between 4 and 5 db. At the same time the audio will be cleaner with strong signals.

Birdies

Some birdies show up on reception at 3.65, 3.74, 14.24 and 21.2 MHz. Although they normally are of no consequence, most can be reduced considerably by adding a .01 mf capacitor between contact no. 2 and ground foil of the bandpass board. This is the point where three brown filament wires are soldered.

Pilot Lamps

The assembly instructions and part list received by the writer called for the use of #44 pilot lamps (probably due to a printing error). This should be corrected to #47 lamps in order to maintain proper current balance in the filament circuits. The #47 lamps have brown identifying beads and draw .15 a. at 6.3 volts, each. The set should never be operated except with both these lamps on.

The writer would certainly appreciate hearing from other owners, especially concerning similar improvements and proven worthwhile modifications. ■

Antennas [*from page 47*]

a grid-dip meter to the base of the antenna through a one turn loop."

"Very good", I said. "I admire ideas like this. Don't forget that I'll send one of my Handbooks for any suggestion, idea or photograph used in my column".

Pendergast reached over and switched on the transceiver. "We haven't been listening in for over an hour", he said. "I'll bet somebody has created a new country in the meantime, and we have lost out. One has to keep on his toes these days, for all the exciting, new DX that's on the air".

"That's right", I replied. "I've heard the rumor that the Northern California DX Club is on their way to Catalina Island right now. Warm up the rig".

Pendergast raised the shade and looked out of the window. It was still raining very hard, but the wind had died down a bit.

"I guess they'll have to swm", he said grimly.

73, Bill, W6SAI

QRP [*from page 50*]

and if not, a jumper wire between two adjacent pads will provide the necessary space. Pads which serve as a ground connection are drilled thru, and a jumper wire from the pad to the underside foil established that pad as ground. In using this type of breadboard, the physical layout of components can approximate the layout of the schematic on paper, or rearranged slightly. (Some points regarding layout follow below.)

In experimenting with a multi-stage circuit, I usually follow a limit of two stages per board, with inter-connections among boards as is necessary. Two pieces of #18 wire soldered to the ground foil of two boards which have been butt-edged together provide adequate mechanical rigidity as well as minimum lead lengths for other interconnections. A chain of boards is the usual result.

The above approach coincides well with the advisable technique of developing and debugging a transmitter one stage at a time. Once the

WILLIAM I. ORR, W6SAI, ON

Antennas

I pulled slowly into the driveway and parked the car near the garage. Atop the tower, which was mounted next to the garage, I could see my friend Pendergast. He was locked to the tower with his safety belt and was obviously working on his antenna system. I got out of the car and squinted up into the bright sunlight.

"What are you doing up there?", I called. In reply, Pendergast yelled, "Heads!!", and tossed down a handful of tools and rusted nuts and bolts which landed with a thump at my feet. "I'll be right down", he shouted as he unfastened the safety belt and began his passage down the latticework tower. When he reached the ground he was puffing.

"You are certainly out of shape", I observed. "A fellow your age shouldn't go about climbing towers like a 20 year old lad".

Pendergast gave me a disdainful glance as he slid out of the safety belt.

"Nonsense", he replied. "A little exercise never hurt anyone. And it is a good idea to look over all the antenna hardware once the winter season is over. Look at these turnbuckles and bolts! All very, very rusty. I've replaced them all, and the tower is ready for another year of hard DX work!"

"Agreed", I replied. "And now you can come over and do the same maintenance work on *my* antenna".

Pendergast ignored the invitation as he wiped his hands on a dirty cloth. He glanced at the car, and asked, "Anything interesting in today's mail?"

"Yes", I replied. "I just received the January issue of *Radio Communication* from England by slow boat. What a great magazine! And this issue has some real good antenna dope in it. You should subscribe to it[1]."

"What's in the January issue that is of interest to antenna buffs?", asked Pendergast, as he tossed the dirty cloth onto the seat of my car.

"Well, 10 or 15 years ago DL1FK designed a two-band dipole. It was described in various magazines and also in my *Beam Antenna Handbook* (fig. 1). I always thought this was a nifty way of working a dipole on two bands. But the idea died. It never caught on".

"How does it work?", asked Pendergast. He walked into the shack, took a copy of the *Handbook* from the shelf and turned to page 133. "Here's what you said about the DL1FK antenna", and Pendergast read:

"The complete antenna element is made self-resonant at the highest frequency of operation. At some lower frequency the element is center-loaded by a parallel tuned circuit consisting of the center of the element, a capacitor connected across the element, and the connecting leads of the capacitor. The element (which is slightly more than ½-wavelength long at the highest frequency) presents a capacitive reactance across the tuned circuit at the lowest frequency of operation. This reactance, plus the reactance of the parallel capacitor are sufficient to resonate with the inductance of the center loop at the lowest operating frequency. At the highest frequency of operation, the tuned circuit exhibits a capacitive reactance which is nullified by lengthening the element a slight amount".

Pendergast placed the Handbook on the table and picked up the issue of *Radio Communication*. "I see that Pat Hawker's *Technical Topics* carries this idea a bit further", he observed. "The discussion comes from

[1]Membership in the Radio Society of Great Britain, plus their magazine, *Radio Communication* costs $15.50/year. Application is made to General Manager G.R. Jessop (G6JP), R.S.G.B., 35 Doughty St., London WC1N TAE (England).

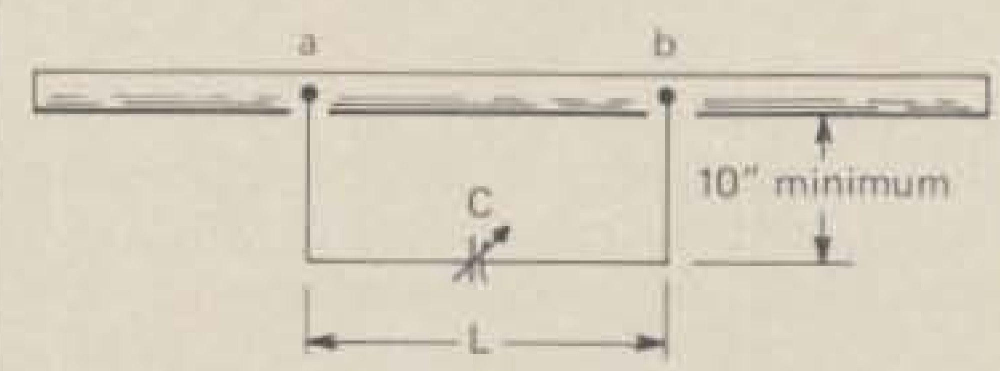


Fig. 1—Representative half-wave dipole or driven element of parasitic beam designed for two frequency operation. Capacitor C in conjunction with the inductance L between points a-b provides a resonance from 0.5 to 1.0 octave above the fundamental frequency. Connections to the capacitor are made with tubing of ¼-inch to ½-inch diameter for a tubing element of 1¼-inch diameter. For 14 MHz, the distance a-b is about 7 feet and capacitor C is about 90 pF.

Les, G6XN, who has done a lot of original work and development with aerials—that means *antennas* in America", said my friend.

"Thanks", I replied. "You are a big help".

Pendergast continued to read from the magazine:

"The illustration (fig. 2) shows how

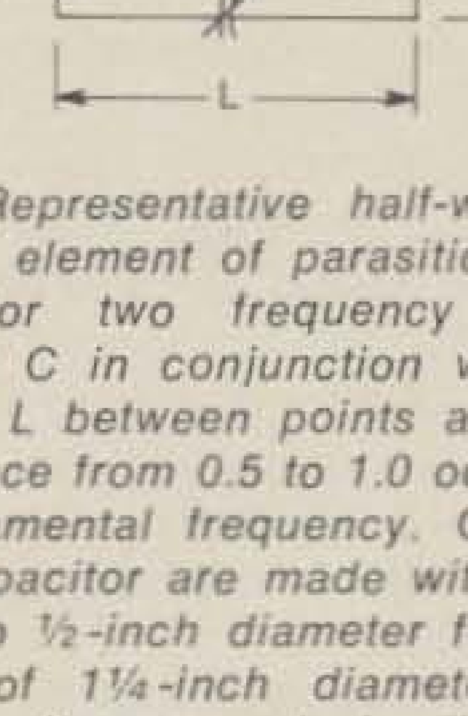


Fig. 2—A 14 MHz element can be resonated at 21 MHz by capacitive loading and at 28 MHz by a combination of L and C. To convert antenna (b) into antenna (a) the capacitor C can be increased so that it turns out L in addition to the inductive reactance of the dipole. However, the presence of L has considerable effect on the fundamental 14 MHz resonance and this must be compensated by series capacitance at points X-X or by shortening the dipole.

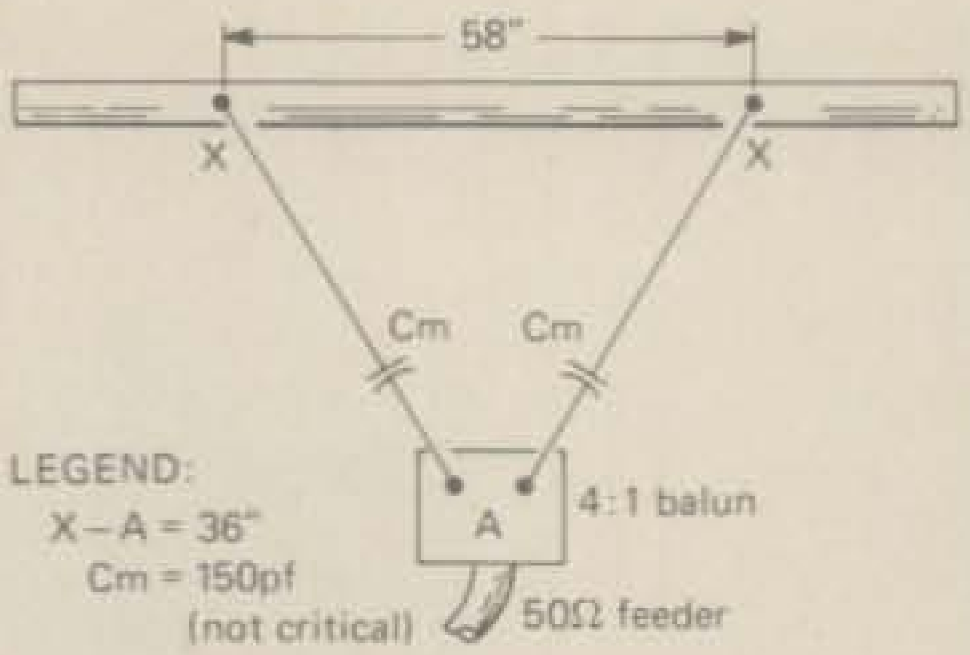


Fig. 3—The G6XN balanced feed system for a multiband driven element. With reference to fig. 1, the capacitor has been split in two and the inductor L has been brought off at angles from the dipole to form a matching device that permits a good match to a 50 ohm unbalanced transmission line via a 4-to-1 balun.

a 14 MHz element can be resonated at 21 MHz by capacitive loading and at 28 MHz by a combination of *L* and *C*. To convert antenna (b) into antenna (a), capacitor *C* can be increased so that it tunes out *L* in addition to the inductive reactance of the dipole. However, the presence of *L* has considerable effect on the fundamental 14 MHz resonance and this must be compensated by series inductance at points X-X or by shortening the dipole.

"Using these techniques, the end product of this approach is the antenna of fig. 1. This antenna can be resonant at 14 MHz, yet span 21 MHz to 28 MHz by adjustment of capacitor *C*. The element is resonated at its higher frequency by the capacitor acting in conjunction with the distributed inductance *L* represented by the section of the element across which *C* is connected. Matching to a driven element is no great problem, G6XN reports, since the radiation resistance of the dual-frequency element, when expressed as a resistance in parallel with *L*, has (or can easily be arranged to have) comparable values at each of the operating frequencies. The feed resistance between any two points along *L* *tends* to be independent of frequency. The beauty of the system is that the capacitor has virtually no effect on the basic dipole resonance (say 14 MHz) except for a slight, and potentially useful, shift in band-center frequency of the order of 1 percent when a 14 MHz element is being used and *C* is given the appropriate value for 21 MHz."

Pendergast interrupted himself, thought a moment, and then said, "It seems to me that an element such as this should provide some signal gain on the higher frequencies".

"Read on", I invited.

Pendergast continued reading:

"Since the full aperture of the element is used on all frequencies this means that a 14 MHz element can itself give up to 2 dB gain at 28 MHz and up to 1 dB at 21 MHz. There are, of course, no traps to incur losses or to require supporting in the elements, so simplifying construction. When applied to a Quad, as much as 3 db extra gain may be achieved at 28 MHz, plus freedom from the interacting effects of 'nested' elements".

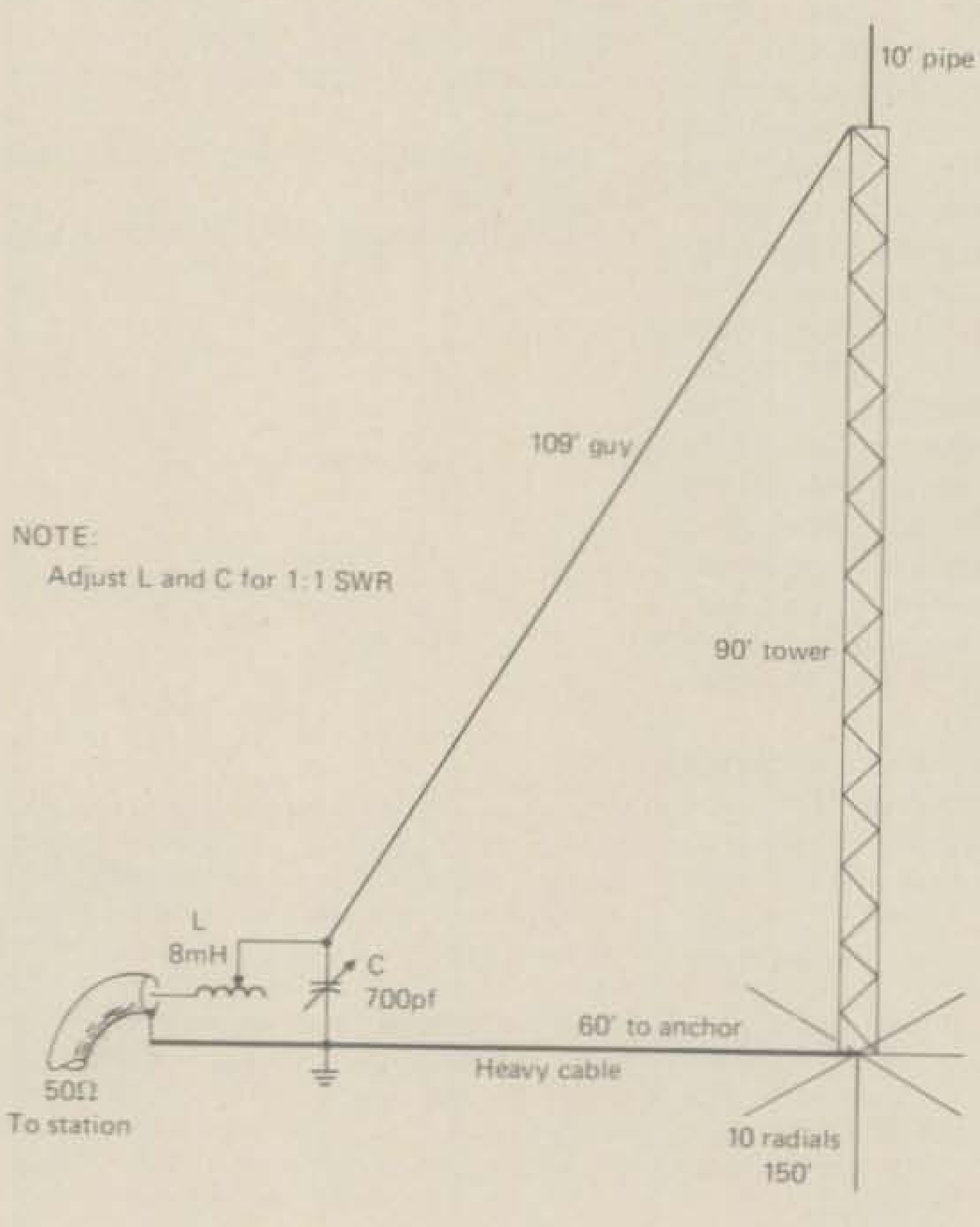


Fig. 4—The W3IN folded unipole for 160 meters. The 90 foot tower is shunt-fed by one of the guy wires. A ten foot extension atop the tower provides a bit of top loading and improves the match at the base of the guy wire. A simple L-network is used to resonate the system. Ten 150 foot radials provide a good ground screen.

"This is really a very clever idea", I said. "As G6XN points out, dual frequency operation is very simple and tri-band operation seems possible if the user is willing to adjust the value of capacitor *C* when changing bands.

"It seems the experimental work was done on a three element 14 MHz Yagi, with the element arrangement shown in fig. 1. A dual band beam was achieved by simply stringing a capacitor on each element, as indicated in the drawing. For the 14 MHz element, the distance a-b is about 7 feet and the capacitor is about 90 pf. G6XN started out with receiving-type capacitors until he achieved the resonance points he desired and suggests that the capacitor have a 2 kv rating for legal limit operation.

"While element spacing may not be optimum for the higher band, it is not critical and gain is good. Front-to-back ratio, however, seems to suffer with the greater spacing between elements, when the antenna is operating on the higher frequency band."

"Very interesting", commented Pendergast. "How did G6XN feed his dual-band driven element?"

"Look at fig. 3", I replied. "G6XN modified the shunt capacitor arrangement into a triangular shape, and used two capacitors, one in series with each leg. The feed point is at the junction of the capacitors".

"So by placing capacitors on the reflector and director of a 20 meter Yagi, as shown in fig. 1, dual band operation is achieved for these elements. And by using the arrangement of fig. 3 on the driven element, the beam can be fed and matched on two bands," said Pendergast.

"That's about it," I replied. "Of course, no guarantee can be given of equally low s.w.r. on both bands, but there's plenty of room for experimentation. I hope some reader of my column has the time and desire to experiment with this novel idea, as it looks as if a dual-band Yagi can be built up without the use of lossy traps or messy stubs. I like this concept, and hope to have more information on it in the future. Hats off to G6XN and G3VA for a noteworthy contribution to the search for a multi-band antenna."

Pendergast sighed, then he said, "I wish some of these smart fellows would come up with a good antenna for 160 meter DX for me. I am still using a loaded, 60 foot wire and I can't punch my way out of a paper bag. Have you received any mail on this subject?"

"Yes," I replied, "I have. In fact, I got a fine note from Don, W3IN, who did the summary of the 160 meter DX contest in the December issue of *CQ*. Don has worked 72 countries on 160 meters and was among the top ten high scores in both the *CQ* and the ARRL contests for the past few years. So he qualifies as a DXpert on the top band!

"Don has a 100 foot, guyed tower, top-loaded by a 10-foot "star" made of metal rods. He lights it up at Christmas, too—"

"With R-F?", inquired Pendergast.

"He doesn't say," I replied. "To continue . . . Don says the tower needs guy wires to hold it up, so he uses one of the top guys as a feeder. This transforms the tower into a version of a folded unipole (fig. 4). He places a strain insulator at the ground anchor of one guy and feeds it with an L-network placed in a weatherproof 'dog house' at the foot of the guy. All the other guy wires are broken up with strain insulators, and the top portion of the guys are bolted directly to the tower to act as additional top loading. A heavy cable is buried from the tower base to the feed point to keep the loop resistance low. And, in addition, ten 150 foot radials are laid along the surface of the ground and connected to the tower at the base. A photograph of the installation is shown in fig. 5.

"Don uses a surplus roller coil with 8 millihenry inductance in the matching unit. The capacitor is a three-gang broadcast variable unit, as the voltage across it is quite low. He fed the tower with a few watts of power at 1825 kHz and adjusted the coil and capacitor for minimum s.w.r. on the feed line. He says the s.w.r. is quite low across the whole 160 meter band from 1800 kHz to 2000 kHz."

"Well I heard Don, W3IN, during the last 160 meter test. He put one helluva signal out here in California," said Pendergast.

"Well, he may not be so loud now," I replied. "In his letter, he says he is experimenting with a parasitic director aimed on Europe. It is suspended from a cable between the 90 foot tower and an 80 foot tower about 200 feet away in the desired direction. An insulated 60 foot top-loaded horizontal portion plus a 75 foot down-lead is used for the director, shaped like a T-element. A roller

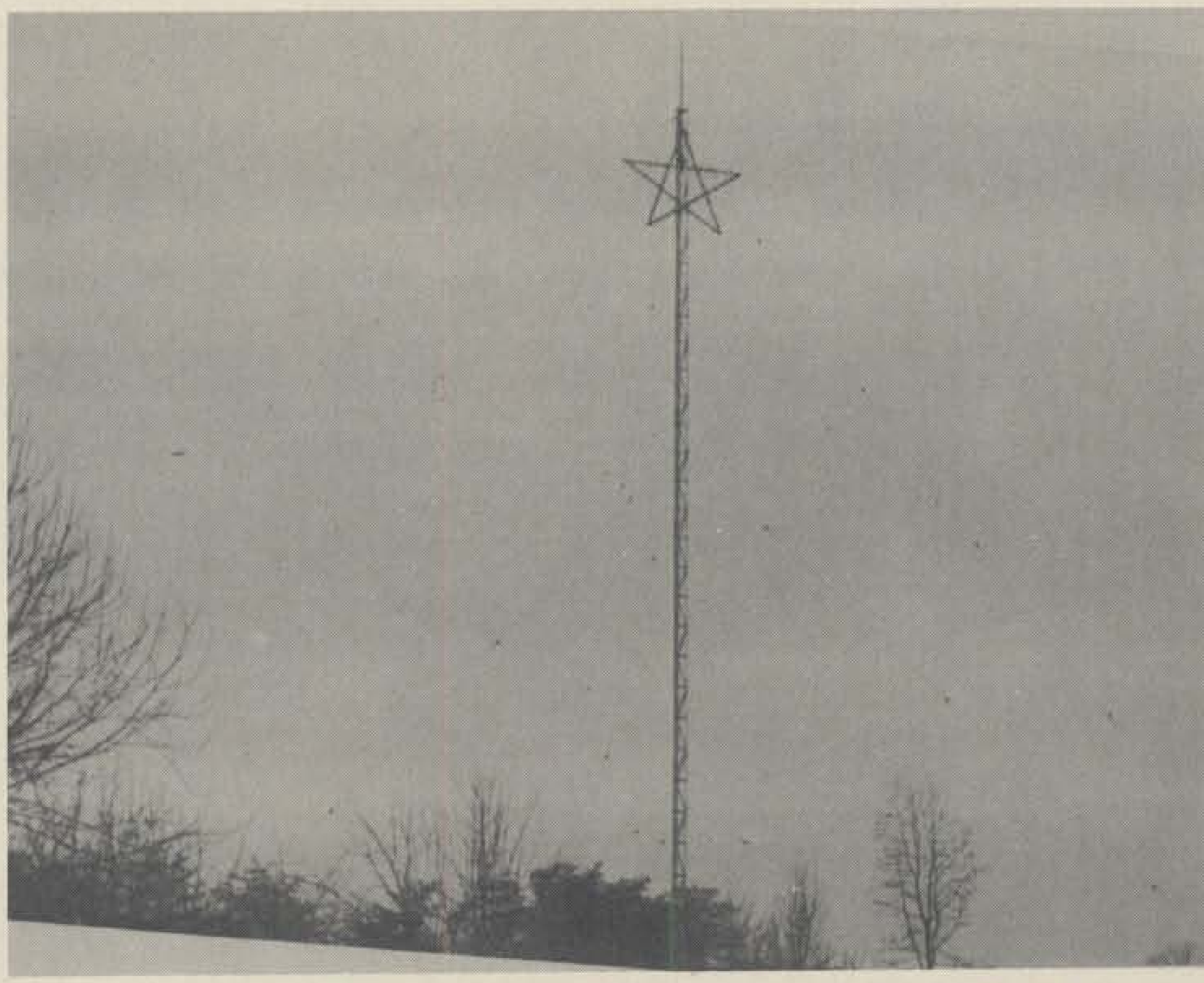


Fig 5.—Neighbor's view of the W3IN folded unipole for 160 meters.

coil from the bottom of the vertical wire to a second set of radials provides the tuning adjustment. A remote relay shorts out the roller coil when a circular pattern is desired. The gain is not spectacular, but on 160 meters, every bit helps!"

"I'd certainly love to put up something like that," said Pendergast, with a wistful tone in his voice. "It's tough to be loud on a city lot."

"Well, you are a lot luckier than some fellows I know. I got a letter from Jerry, W4IOW/4. He's going to North Carolina State College and lives in a two story, wood frame apartment building. No antennas allowed, naturally. So Jerry merely tossed a small diameter wire across the roof of the building (fig. 6). The antenna lies hidden on the roof and dangles a few feet down the opposite side of the building. He brings one end of the wire in through the window to an L-network and uses the heating system which runs around the baseboards of the room as a ground. He says the simple antenna works well on 40, 20 and 15 meters. He doesn't know how long the wire is, but guesses it is about 35 feet long, judging from the width of the building."

"Necessity is the mother of invention," remarked my friend.

"Now that we're speaking of end-fed wires, I received an interesting note from 'Speed', W8RKD. He's using an end-fed wire that is high in the center, and low at the ends, somewhat in the fashion of an inverted-V. He feeds it with a pi-network, through a coax bridge. He notes that the minimum s.w.r. changes with the weather. During the dry season his s.w.r. is near unity and in wet weather it rises as high as 1.5-to-1. I have noticed that the s.w.r. and also the antenna current on my 160 meter Marconi varies with the dampness of the soil, and I'm pleased to see that someone else agrees with my observations. It proves that the earth under the antenna really exerts a profound influence upon the operation of the antenna."

"Well, I notice that the s.w.r. on my feedline changes when I aim my 20 meter beam into a nearby tree," remarked Pendergast. "And I also notice that the s.w.r. change depends upon the season of the year. The more leaves on the tree—and the more sap in the trunk, I suppose—the higher the value of s.w.r."

"I don't think we know everything about antennas just yet," I observed. One of the things that puzzles me is the often-published graph showing the radiation resistance of a half-wave dipole above ground. Of course, the curve is the theoretical case and may not represent what is going on in real life, where the dipole is suspended above an imperfect ground.

"In any event, the classic curve shows that the radiation resistance of a dipole is about 73 ohms at a

(continued on page 70)

transmission, so look for a "new country" very soon! Incidentally, Ahmed has a two element quad at 65 feet pumping an excellent signal all over the world.

Old friend Richard Thurlow, G3-WW, brings up a good point: What constitutes a valid SSTV two-way exchange? This question arises in connection with DX-Expeditions which do not carry a monitor and obviously cannot verify satisfactory reception of SSTV signals until the tape is reviewed following the expedition. Comments on this subject are invited. Meanwhile, Richard is preparing a proposal for acceptance by BATC, ARRL, and RSGB.

'Way out West in Kansas, Stanley, Kansas, that is, lives a handsome gentleman with an impressive array of amateur gear. Not only that, he's well known in SSTV circles for his excellent picture "programs". The accompanying pictures (figs. 6 and 7) show Jerry Foster, W0QWH, enjoying some "armchair copy" and busy with his nifty program board/camera.

Final-Final

I would like to express my thanks for the continuing support of this column from all over the globe. In addition to bringing you news and pictures of the slow scan world, "In Focus" can also serve as a clearing house for your problems. If you need help with some phase of a construction project or have discovered a means of getting around a common problem, please don't hesitate to drop me a line. "In Focus" hopes to serve as a meeting place for all slow scanners, so keep those letters and pictures coming! 73, Bill, W2DD

Antennas *(from page 41)*

height of one half wavelength. As the height of the dipole above ground decreases, the radiation resistance of the dipole rises, until it reaches nearly 100 ohms at a height of about 0.3 wavelength above ground.

"Well, this represents a height of about 40 feet at 80 meters. And a lot of fellows, including myself, have 80 meter dipoles at that elevation. I can't speak for others, but I've found that the radiation resistance of the dipole at that height runs closer to 30 or 40 ohms than it does to 100 ohms. So, I don't think it is too wise to put too much trust in charts or diagrams that show radiation resistance as a function of antenna height. The imperfections of the average ground prevent such a conclusion from being reached."

"Next thing, you'll be telling me that there's no Santa Claus," said Pendergast with a laugh. ■

WILLIAM I. ORR, W6SAI, ON

Antennas

"Welcome back," cried Pendergast. "How was your vacation in Hawaii?"

"Great!", I admitted. "Lots of beach weather . . . watching the *Wahinis* in their Bikinis . . . that good *Primo* beer . . . Maui potato chips . . . and a little DX to boot."

"I know about the *Wahinis* and *Primo*," said Pendergast, as he settled comfortably down into my operating chair. "Now tell me about the DX."

"Well, it really wasn't that good," I replied. "I got on the air at the start of the *CQ* WPX Contest, right in the middle of the big solar radio blackout! That was a hairy experience.

"The Thursday (March 25) night before the contest started 20 meters was wide open. The VKs and ZLs were very loud, and they had a flutter on them. The signals sounded just like aurora propagation. It sounded like 6 meters, not 20 meters. Also, a lot of deep Asian DX and European DX was coming through with the same flutter."

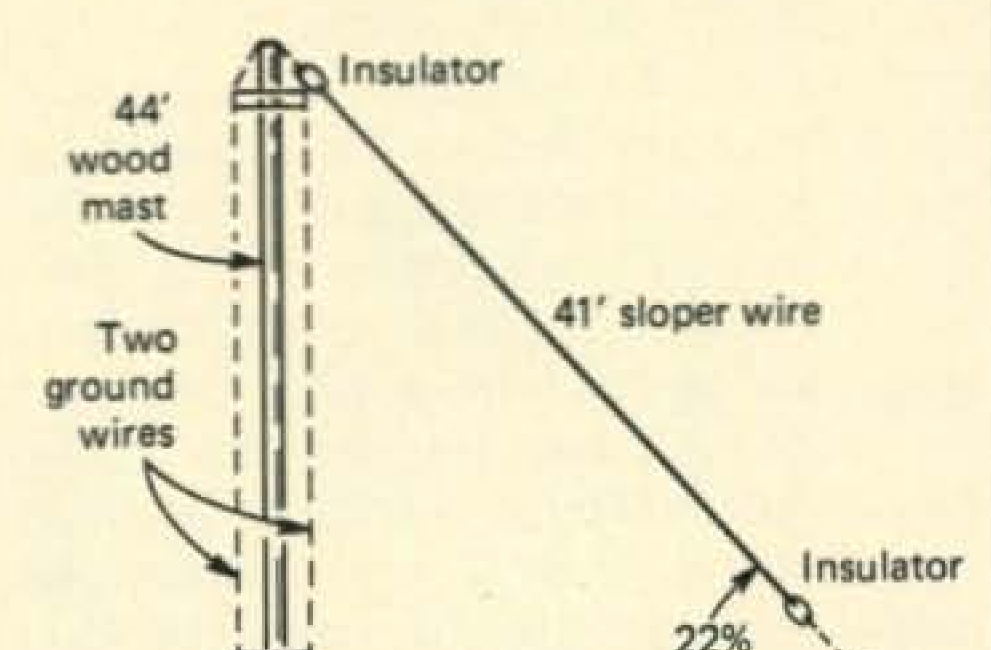


Fig. 1—Inexpensive 80 meter sloper antenna of K6UB. A 44 foot wood mast is used. Two ground wires are brought down from the top of the mast. The 50 ohm transmission line runs up the mast, with the shield grounded to the ground wires. The center conductor is attached to the sloper wire. Length of the wire and the base angle were adjusted to provide the lowest value of s.w.r. at 3800 kHz. A similar antenna is used at WA6PLW.

"What about Friday and Saturday when the contest started?" asked my friend.

"Saturday morning, 20 meters was absolutely flat! Not a signal, except one from South Africa! the ZS6 was the *only signal* on the band, except for one or two locals. Odd that he should come through. Except that he was at the antipodal point on the globe from Hawaii. Possibly his signals were arriving on a north-south path. After he QRT, the band was completely dead for several hours. It began to come back about noon. I talked to Pete, 5W1AZ, in Samoa, and the band came back to life quicker there than it did in Hawaii.

"The first signals I heard from the States were W7s in Washington, VE7s in British Columbia and W6s in the San Diego area. The whole middle section of the West Coast—from Oregon to Los Angeles—was blacked out. Then, slowly, the blacked out area shrank. I began to hear Los Angeles and Oregon. Then stations in central California. The last area to come through was around San Francisco. I didn't hear anything from the San Francisco-San Jose area until about four in the afternoon."

"That's weird," pronounced Pendergast.

"I agree. We are still victims of the ionosphere, for better or worse. And that's what makes DXing a lot of fun . . . the unpredictability of it."

"George Jacob's *Mail-A-Prop* hit it right on the nose," said Pendergast. "He predicted the disturbance, stating the radio storm would begin on March 25th, and said "the bands would be in pretty bad shape." That was the understatement of the year."

"*Mail-A-Prop* is a very handy operating aid for the DXer," I replied. "It saves a lot of wear and tear on the nervous system."

Pendergast sighed, relaxed, and placed his feet atop the polished surface of my operating table. He pushed the electronic key aside with the toe of his boot.

"What's in the mail today?" he asked.

"Well," I replied, "There's still a lot of interest in the 80 meter sloper antenna. That's the quarter-wave wire that uses the supporting tower as a return ground (fig. 1). A lot of fellows are using it, and it seems to be working well for them. As far as I know, W6NLZ was the originator of the antenna.

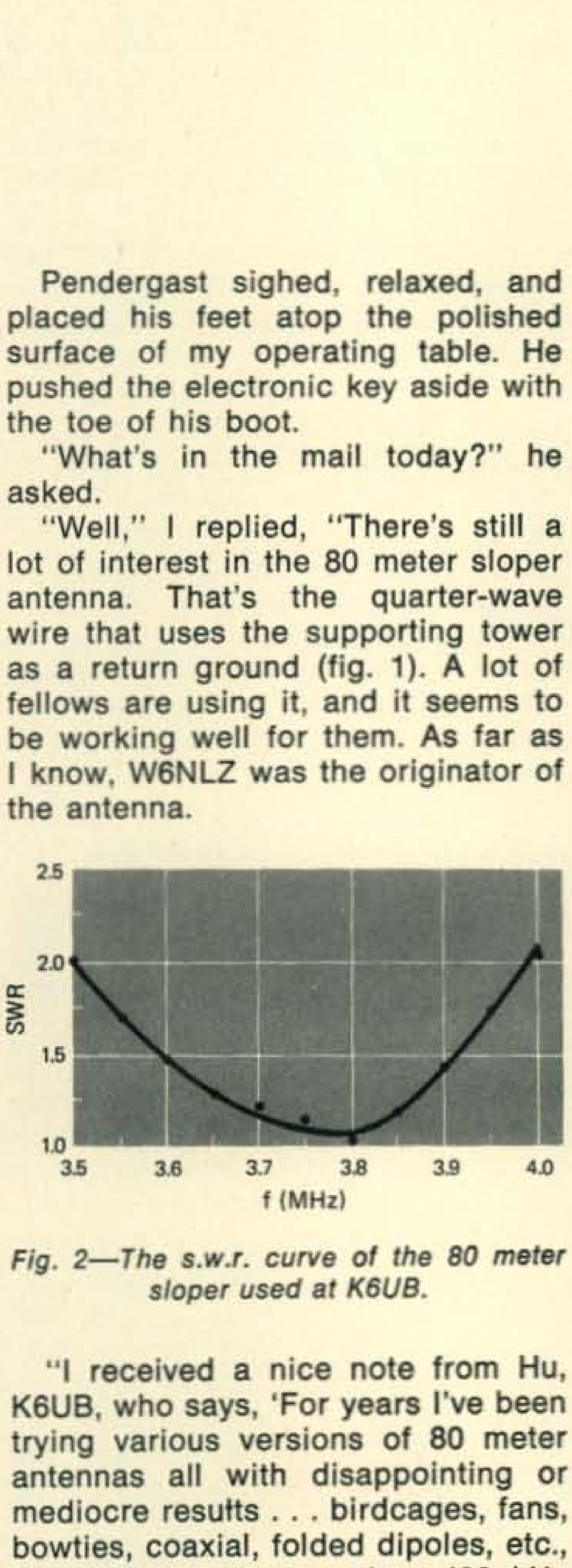


Fig. 2—The s.w.r. curve of the 80 meter sloper used at K6UB.

"I received a nice note from Hu, K6UB, who says, 'For years I've been trying various versions of 80 meter antennas all with disappointing or mediocre results . . . birdcages, fans, bowties, coaxial, folded dipoles, etc., etc. with never more than 400 kHz bandwidth, and usually less.

'Recently I tried out a sloper at WA6PLW. I had to trim the wire to 48 feet to resonate about 3750 kHz. The s.w.r. was 1.4-to-1 at resonance and about 2-to-1 at the band edges. On the air tests brought good reports.

'This encouraged me to try it at my own QTH. I have a 44 foot wooden mast, so I hoisted the sloper to the top and brought down two ground wires in lieu of the metal tower. I grounded the two wires to separate

ground rods and also grounded the coax braid at this point and connected the whole works to the irrigation pipes in the sprinkling system and to a low, woven wire fence!

'To get best bandwidth, and to hit resonance at 3800 kHz, I trimmed the sloper wire to 41 feet and set the angle at about 22 degrees (fig. 2). On the air reports were excellent and the whole 80 meter band is covered with an s.w.r. of 2-to-1, or less, across the whole band. Thanks for a great idea!'

"No credit to you," observed Pendergast archly.

I ignored the thrust, and continued. "Here's a second note about the W6NLZ sloper from Bob, WB4-DPG/5. His sloper is pictured in fig. 3. He says the effect of guy wires on the sloper is worthy of interest, as he has achieved directivity by the proper placement of tower guys. He also says that the feedline should run down the tower to the ground, and then take off to the shack. If the feedline is taken off the tower at a point above the ground, or is brought off at an angle to the antenna, there's a good chance the shack will be full of r.f., with the attendant feedback problems. This holds true for other feedlines to any antennas on the same tower as the sloper. They should be brought to the bottom of the tower, near the ground, before they take off to the shack.

"Bob says that he can tune his sloper on 40, 20 and 15 meters using a Drake MN-4 Transmatch with very little trouble. He's sure the s.w.r. on the line is quite high using this stunt, but he's only running about 200 watts and nothing gets hot, or gives any problems."

"Very interesting" remarked Pendergast. "Obviously the sloper antenna is an unusual one, and we haven't learned all the tricks about it yet."

"Anyone can play," I replied. "The ground rules are simple. The wire is about a quarter wavelength long, or less. The height of the feedpoint above ground, the included angle and the height of the end of the antenna above ground are the variable factors, none of which seem very critical. One or more of these dimensions is adjusted to provide the lowest s.w.r. at the desired operating frequency and the best bandwidth. S.w.r. at resonance seems to run in the range of 1.2-to-1 to 1.5-to-1. The base of the supporting tower should be grounded and all other wires and cables on the tower should be brought off near ground. And, finally, supporting guys on the tower

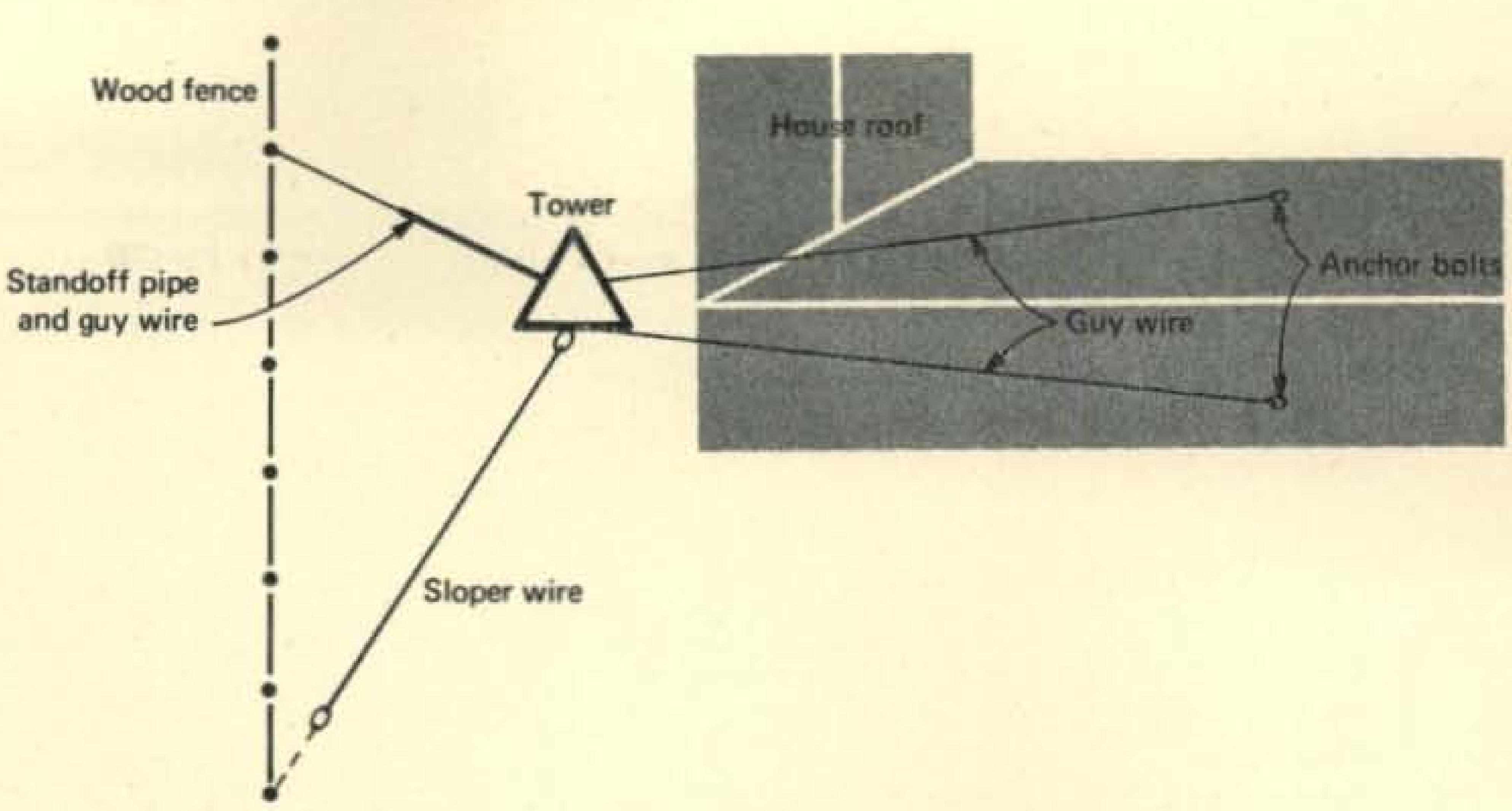


Fig. 3—The 80 meter sloper of WB4-DPG/5. The sloper acts as one guy for the metal tower. Two guys run to anchor bolts in the house roof. The fourth guy is run from the tower top to a standoff pipe on the tower and then down to the base of the fence. This is done to keep the guy wire on the property. Using an antenna tuner, the sloper works well on 80 thru 15 meters. The guy wires are not broken with insulators and tend to act as reflectors for the sloper antenna.

should be broken up with strain insulators, otherwise they impart a directive effect to the sloper. You can take it from there."

"Has anybody used the sloper on 160 meters?" queried my friend.

"Not that I know about, but one cut to that band should work OK, I would think." I paused and sorted through a stack of letters.

"Here's an interesting note from Rick, W6TAT. He's using a short, loaded dipole on 160 meters, which gets away from the radial and ground problems (fig. 4). The compact dipole is only 80 feet long, with 20 foot end sections. The feed system is the balanced counterpart of the popular tapped-coil match used for mobile whip antennas. The operational bandwidth is about 100 kHz between the 2-to-1 s.w.r. points.

"The adjustment procedure is simple. Before the feedline is attached, the antenna is resonated to the center of the operating range by pruning the center coil, while grid-dipping it. Next, the braid of the coaxial line is attached to the center of the coil and the center conductor of the coax is tapped at a point on the coil which provides a 50 ohm match. This adjustment can be done with a Noise Bridge or an s.w.r. meter. If adjustments are done with the antenna low enough to reach the center coil, it may be readjusted by trimming the end tips once it is hoisted into final position."

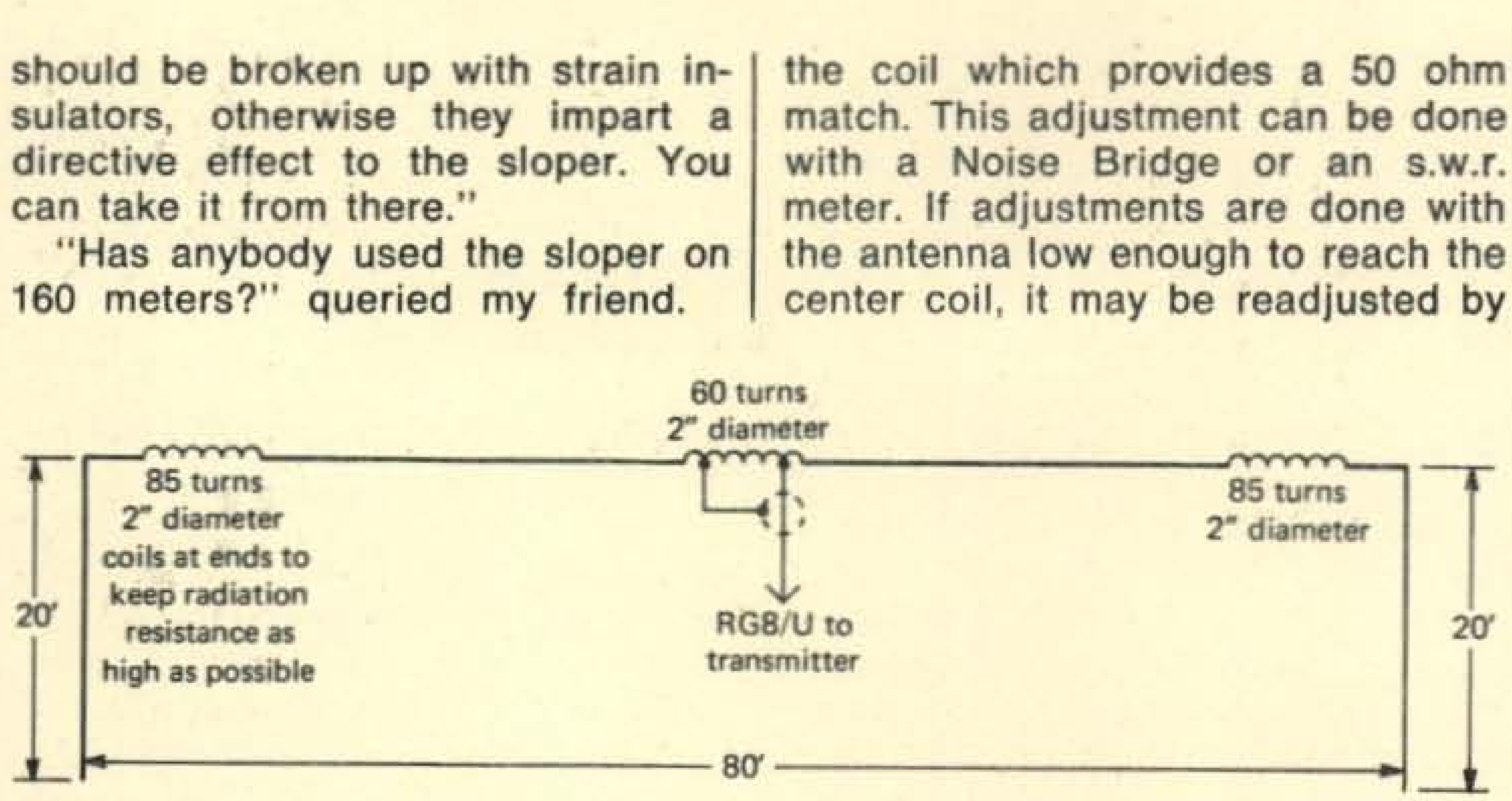


Fig. 4—The W6TAT compact dipole for 160 meters.

"I like that antenna," said Pendergast. "Most fellows have problems on 160 meters because they use some sort of vertical, or Marconi, and run into huge ground losses." He scanned the letter, "Rick says that this mini-dipole provides reports equal to his vertical antenna and he gets excellent signal reports with his schedules, which run out to about 400 miles."

"It should be good for a lot better DX than that," I remarked with a smile.

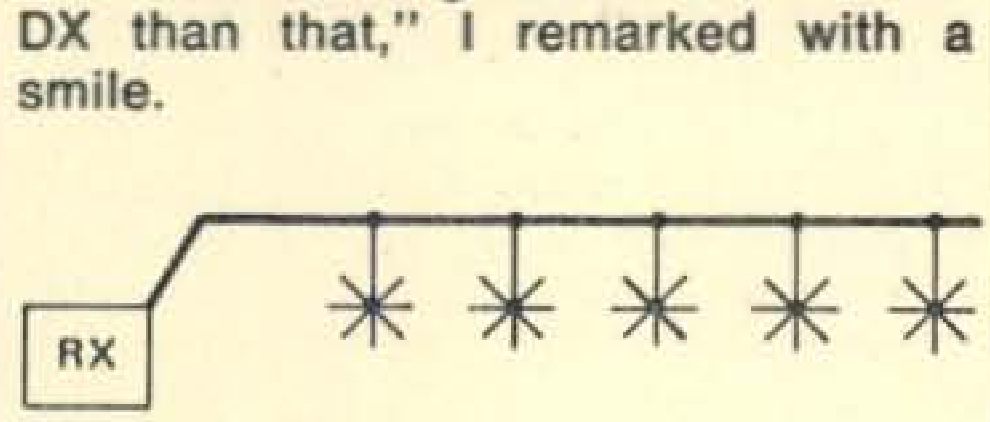
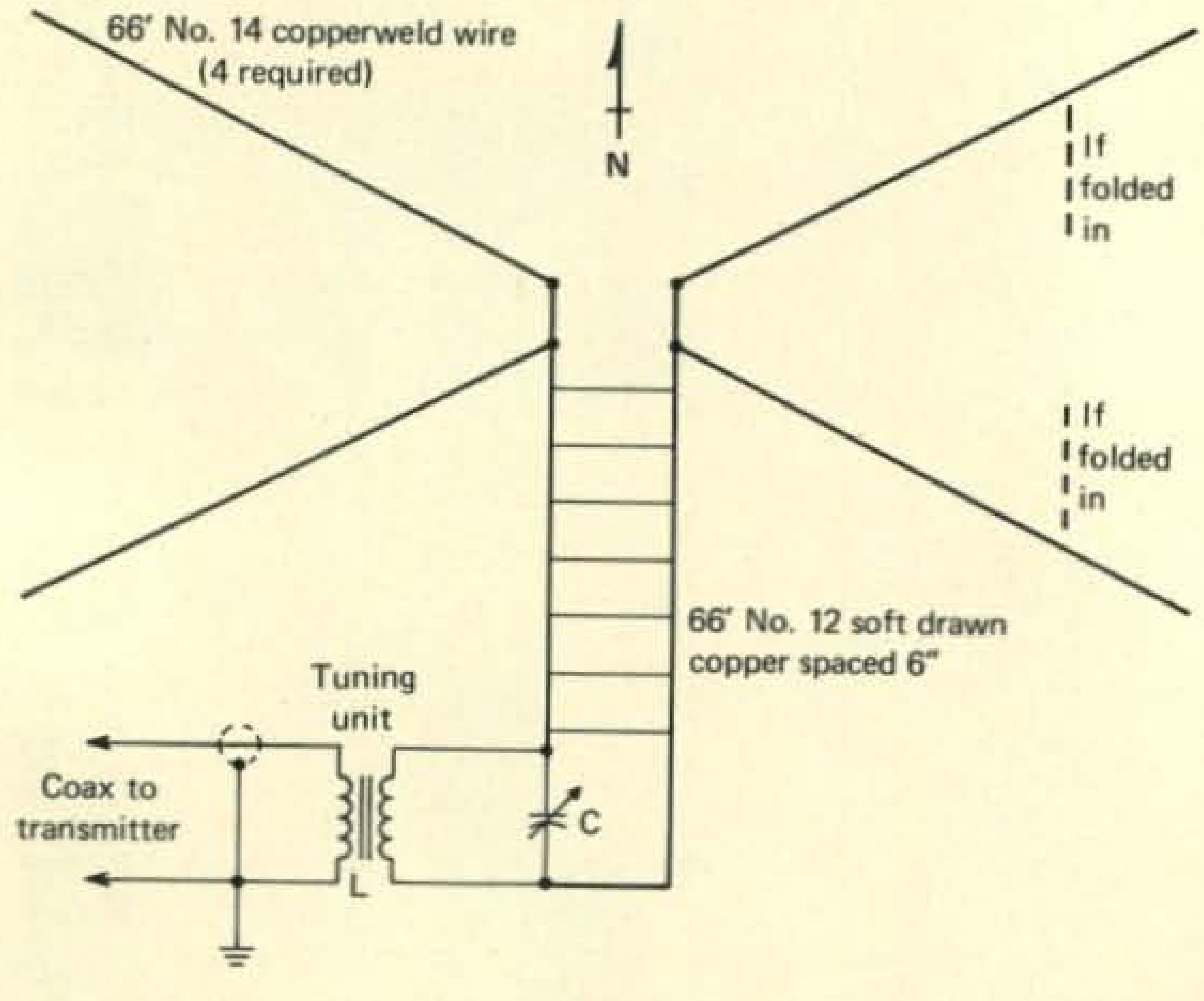


Fig. 5—The old timer's "cat whisker" receiving antenna of the "twenties" remembered by WA4LCO (ex-W8LCN).



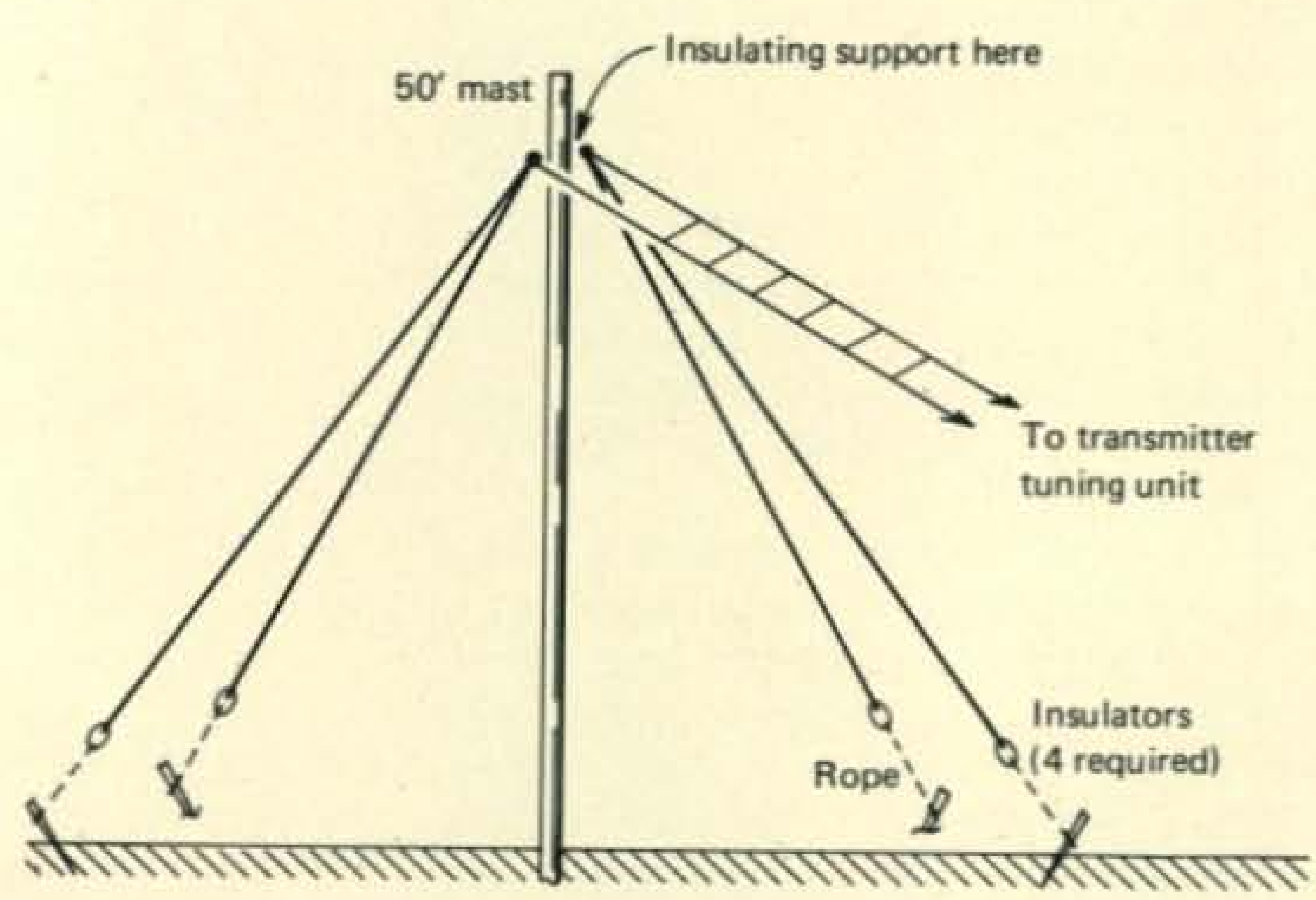


Fig. 6—The WA4LCO multiband antenna. This center-fed, double inverted V antenna works 80 through 10 meters. It is supported on a 50 foot push-up TV mast. A 66 foot long, spaced feeder system is used in conjunction with a simple antenna tuner. The L-C combination tunes to the band in use. WA4LCO has made 5-band DXCC with this simple antenna.

"Before we leave low frequency antennas, you might be interested in the letter from Ken, WA4LCO. Ken says, 'My earliest recollections of radio were the days when everybody built their own equipment (BC as well as amateur). My father assembled his own variable capacitors and my uncle made his own audio transformers by taking a bundle of iron wires, winding primary and secondary around the middle of the bundle, then bending the ends of the bundle around the windings to interleave outside the windings and complete the magnetic path.

'My uncle also had his favorite receiving antenna (fig. 5) which he called a "catwhisker aerial." Every so often a short piece of wire was soldered to the antenna wire and at the end of the wire, six or eight shorter pieces were soldered and stuck out in various directions. This was in the early twenties. I guess the idea was to get as much copper in the air as possible.'

"Wild," said Pendergast.

"The antenna that WA4LCO uses has a lot of copper in the air, too (fig. 6). It is a center-fed, double inverted V, using tuned feeders and a *Matchbox* tuner. Ken has 5BDXCC with it. Not bad! He says the antenna works well 80 thru 10 meters and does not seem to show any directional effects. Only one support is required, and he uses a 50 foot telescoping TV mast. Two antenna ends are tied to a fence and are only about 5 feet above the ground. The other two ends would normally land in the front yard, but he didn't want them there, so they are bent back and run along the edge of the roof. Ken says the whole thing is fairly inconspicuous and several neighbors have asked him when he was going to get his TV antenna mounted on the mast! Ho, ho."

"That's a nice antenna that can disguise itself as a TV mast," remarked Pendergast. "A TV antenna could go at the top, and the feedline could come down inside the mast, if that shielded 300 ohm line was used!"

"Pretty sneaky," I replied. "But sometimes subterfuge works wonders in an up-tight neighborhood!"

Pendergast's attention seemed to stray, and he did not reply. Instead he rose out of the chair and in one gesture reached up on the shelf and clutched a small object.

"What's this gadget?" he demanded, examining it closely. (Fig. 7).

"It's a mini-s.w.r. meter," I replied. "In this age of rising costs, it is the *Buy of the Month*. About ten dollars."

"A bargain," remarked my friend. "What's inside the case?"

(Continued on page 72)

Fig. 7—The new Swan miniature s.w.r. meter sells for about ten dollars. Just the thing for portable or Field Day use. It is rated to 1 kilowatt up to 21 MHz and 500 watts up to 30 MHz.

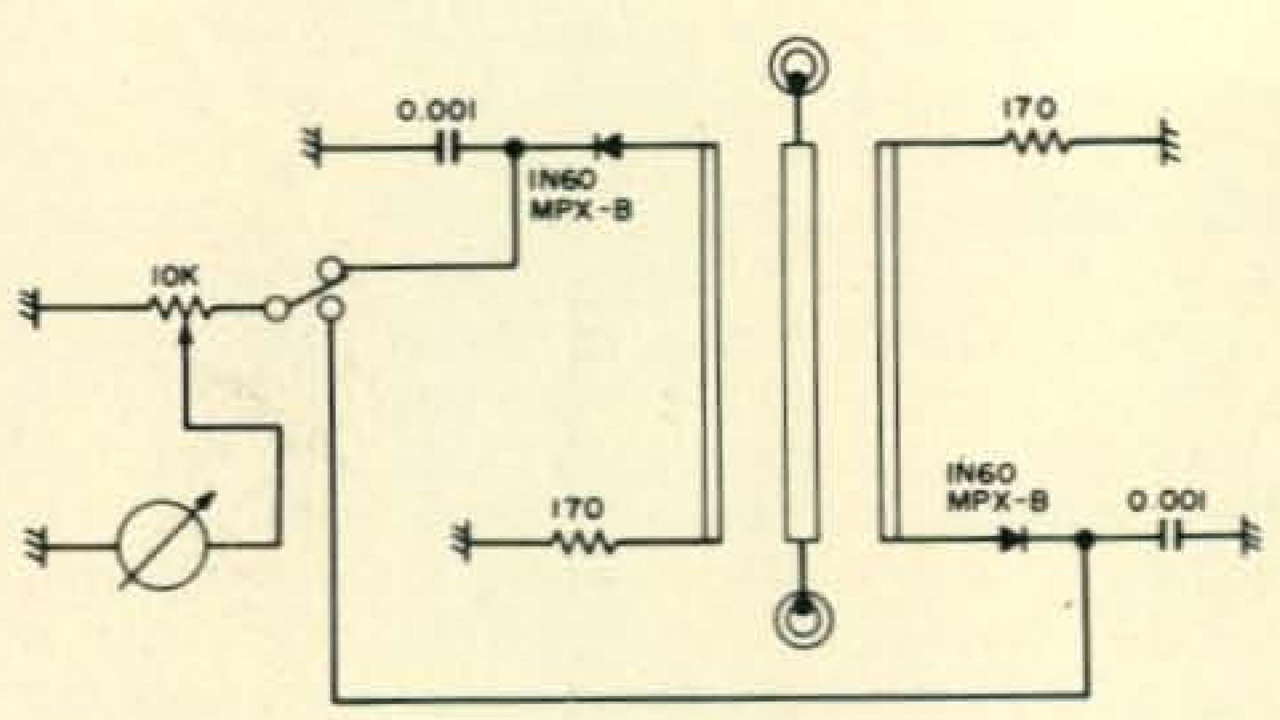


Fig. 8—Schematic of the miniature s.w.r. meter. Components are mounted on a compact printed circuit board.

beautiful—it looks like some huge prehistorical eagle landing on my mast with wings outstretched. If you are looking for a cheap, dependable, and effective antenna, this could be it.

73, Ade, K8EEG/Ø

Novice *(from page 50)*

(Novice) and Element 3 (General, Conditional, and Technician) class written exams; so look for new License Manuals incorporating the new material shortly. The new study guides suggest the areas the student should study, rather than listing many sample questions, without changing the scope of the exams to any appreciable extent.

We will be looking for your News and Views, suggestions, entries for our Photo Contestant any other material of interest to the young of heart. Send all mail to: Herbert S. Brier, W9EGQ, Novice Editor, CQ Magazine, 409 S. 14 St., Chesterton, Ind. 46304.

Antennas *(from page 48)*

"It is the new Swan SWR-3 Pocket s.w.r. meter," I said. "Good for a kilowatt below 21 MHz, and 500 watts up to 30 MHz. It is rated to 55 MHz."

Pendergast reached for a screwdriver and started to remove the case.

"You don't have to remove the cover. The schematic is very simple (fig. 8). It is an uncomplicated version of the strip-line s.w.r. device, made up on a printed circuit board. Basically, it is composed of two directional couplers, back to back. One coupler is used for forward readings, and the other for reverse readings. The basic design was described several years ago in *QST* magazine."

"That looks like just the instrument for Field Day," exclaimed Pendergast as he removed the cover and peered into the little box. After a moment, he replaced the cover.

"I'll drop down to *Friendly Bob's Place* and pick one up. There's not much left in amateur radio that you can get for ten bucks." He paused as he headed for the shack door.

"What do you think about the Sunspot Cycle?" he asked. "When is it starting to go up?"

"Well," I replied, "My uneducated guess is that we will see the sunspot count starting up in August, 1976. I won't know until some time after that date that I have guessed right, but I'll make a modest wager that August will be the turning point. But conditions won't magically improve right after that. But by fall of 1977, I would

think that things would be on the upswing, especially on 15 meters."

"How about 10 meters?" asked my friend.

"Maybe spring of 1978. That will give you plenty of time to get that new 10 meter beam working."

Pendergast smiled. "10 meters is my favorite band. Plenty of newly-licensed amateurs have never experienced the great DX days on 10 meters at the peak of the last sunspot cycle. They will have a big surprise and thrill in store for them."

"And what about the 11 meter CB band?" I asked. "What do you think will happen to *that* when the sunspot count goes up?"

Pendergast shuddered. "I remember it about 10 years ago when there were fewer CBers than there are now. It was a madhouse then. I can't imagine how horrible it will be in a few years. I hope some of the smart, savvy CBers will become amateurs before that unhappy time arrives." ■

In Focus *(from page 53)*

not being able to adjust their non-existent diaphragms!

Faster films like Kodak Tri-X Pan and Polaroid's 107 require some means of reducing the amount of light flux reaching the film.

I'll discuss exposure control for these films, film speeds, and further info on close-up lenses in upcoming columns. In the meantime, go ahead and TRY SOMETHING!

Worthwhile Photographic Book

If there are any professional photographers out there among you slow scanners — or advanced amateur photographers, Kodak has a new book out called *Kodak Professional Photoguide*. It is also called *Kodak Publication R-28*, sells for about $8.50, and believe me, it's worth twice the price! It contains every kind of data you could possibly wish for in all phases of B&W and color photography. It covers Films, Exposure, Filters, Flash, Camera Lenses and Perspective, and even contains a sample gray scale and a color chart, plus eight built-in circular slide rule calculators.

Free Trip To Naples?

Naples, Florida, that is, where Bob Weinig, K4FZ holds forth. I'm sure that not only the equipment but the fine cabinet space available will be the envy of everyone seeing the picture (fig. 5) of Bob's beautifully equipped "shack"! As you can see in the other photo (fig. 6) Bob has engineered a nifty system for televising flat copy material. The three curio picture lights used to illuminate the copy are controlled by a solid state dimmer.

Incidentally, Bob's "menu board" has vertical angle pieces forming slots into which cards 8 inches wide are slipped. The camera track consists of two ½ inch aluminum angles. The camera rolls back and forth on plastic wheels.

Every time I work K4FZ, he's trying something new. Always seeking ways to create more interesting pictures. His latest project is a system for projecting slides onto a translucent screen between the camera and the slide projector. Sounds great Bob, send us some more pictures!

Any More SWV's Out There?

From Uxbridge, Mass. comes a neat card signed by Bill Smith who is a non-ham SSTV viewer. Bill's well-equipped set-up includes a Robot 70A monitor, Drake R4C and SPR-4 receivers, and, a two-element beam at 70 feet! Although Bill describes himself as a short wave listener, I have a feeling that he's a ham at heart. Come on Bill, find someone to help you get a ticket, we need you!

News And Views From Europe

Looking for an OK contact? Josef Psota, of Kosice, is one of Czechoslovakia's active slow scanners. Josef builds all of his own equipment. His homebrewed transceiver uses 30 transistors and 7 tubes. He pumps 75 watts into a dipole suspended 40 meters off the ground between two buildings.

Take a look at fig. 7 showing Josef's homebrewed camera. A very neat job in all respects. The camera circuitry uses 23 transistors. Yes, his monitor is homebrewed too! Thanks to Mike Ludkiewicz, W1DGJ, for the photo and info on OK3ZAS's gear.

From Denmark, an oldie but goodie to wind up this month's column. It was a long time ago that T. I. Pedersen, OZ4IP sent me the accompanying picture (fig. 8) of his "mobile station", but I still get a kick out of it. I hope you will too!

Final-Final

Please keep those letters and pictures coming my way. They are what make this column interesting for your friends around the World, they DO want to know what you're doing even if the band conditions are poor most of the time. As it says in the call-books, W2DD lives at 2112 Turk Hill Road, Fairport, N.Y. 14450.

73, Bill, W2DD

WILLIAM I. ORR, W6SAI, ON

Antennas

"Tell me all about your 40 meter DX," I suggested to Pendergast, as he slid the earphones from his head and turned down the receiver.

"Forty has been pretty good these days," he admitted, as he glanced back through his logbook. "There's almost as much coming through on that band as there is on 20 meters . . . if you have a good antenna."

I glanced over his shoulder at the log. "Well. VR4CW, ZD9GF, UK6LAZ, a bunch of Europeans, Africans, and Asians to boot!"

"Yes," said my friend, "But it is a real hassle. You really need a good beam to be able to compete on 40. Sometimes you can't even *hear* the stuff until you have a beam."

"So your next project is a 40 meter beam. Right?"

"Yes," replied Pendergast. "And the one I am interested in is the new four element *KLM Bandpass* antenna. That should do a really good job."

"It is quite unique," I admitted. "I know of no other antenna of this type. In fact, I just received a letter from a DX'er who has one up. Would you be interested in what he has to say about it?"

"Certainly," replied my friend.

"Well, as you know it is a 4 element job using a pair of log-periodic bandpass driven elements, plus a reflector and a director (Fig. 1). The boom length is about 42 feet and the longest element—the reflector—is about 47 feet. Before we go into details, the letter from my friend says he's been using the 40 meter KLM beam for about six months. He's had a daily sked with South Africa every day and has never missed a schedule due to band conditions. He's worked his schedule as late as 1320 PST, which is *amazing!*

"Sometimes he gets other W6 stations into the schedule on the long path opening. While he's usually S9+, the boys with the dipoles and verticals are just barely out of the noise in South Africa! That performance really separates the men from the boys!"

"Wow," said Pendergast. "A good beam certainly helps on 40."

I looked at the letter again. "He closes by saying that he can't overemphasize the usefulness and consistency of 40 meters. The foreign broadcast signals off the side and back of the beam are reduced and the DX signals really pour in. He's worked a VK5 on sideband who was running *one watt* PEP input and gave him S7. So there you are."

"What's the configuration of the beam?" asked Pendergast, as he pulled out his notebook and pencil, prepared to make notes.

"The layout is shown in fig. 2. The boom is 3 inches in diameter, with top guys fore and aft. All elements are insulated from the boom. The elements are foreshortened by *linear loading,* that is, the elements are folded back on themselves to conserve space. The two driven elements are cross-connected to form a single cell log-periodic structure having a passband of 300 kHz. Feedpoint impedance is about 200 ohms, so a 50 ohm line and a 4-to-1 coaxial balun make up the feed system.

"The passband of the antenna is shown in fig. 3. The log-periodic design acts as a sort of bandpass filter providing a good match and good bandwidth over the whole 40 meter band. Observe that the s.w.r. is less than 2 over the whole range, and less than 1.5 over nearly 260 kHz."

"Most small 40 meter beams have a very narrow operating bandwidth," observed Pendergast.

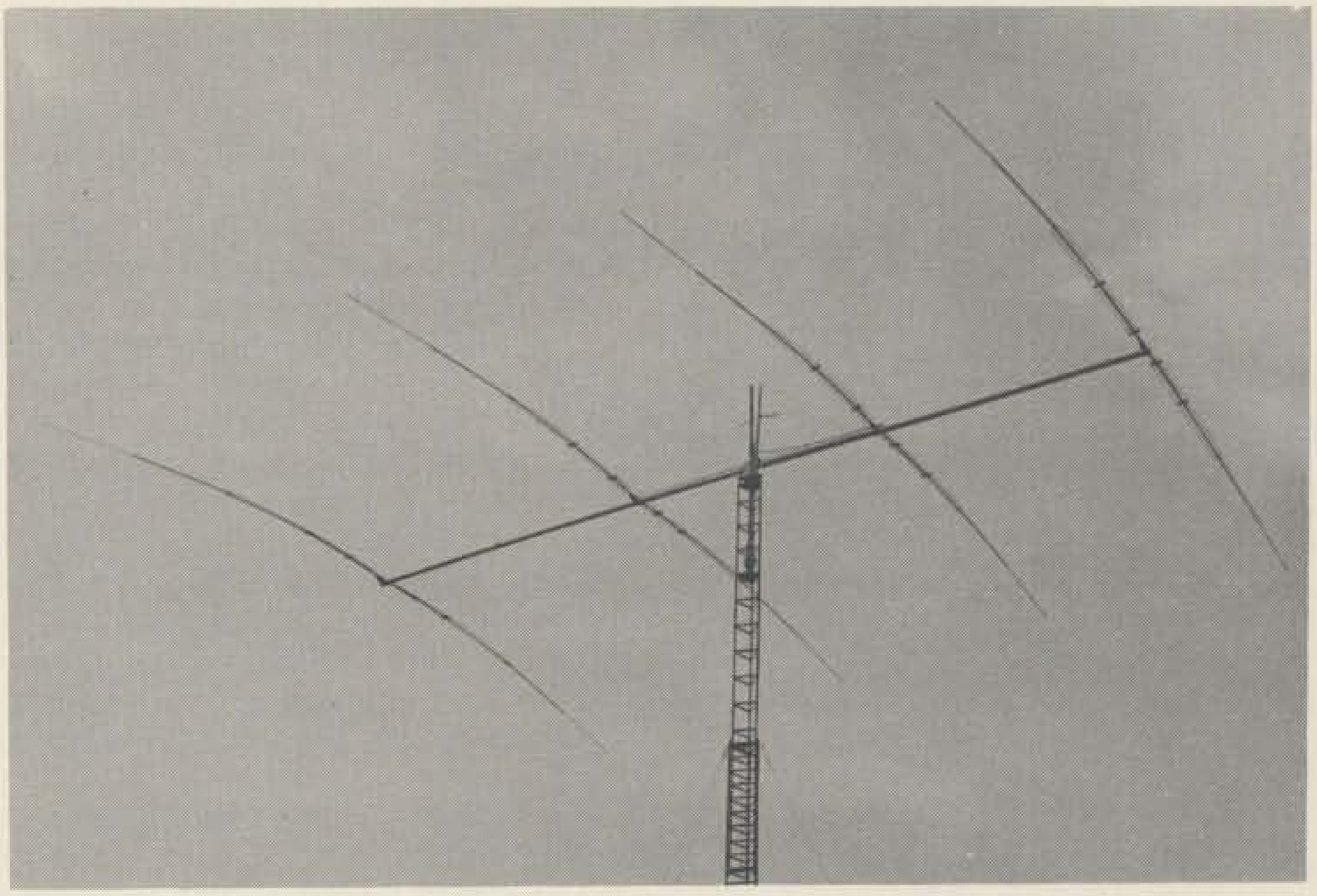


Fig. 1—The KLM bandpass beam antenna for 40 meters. This 4-element array makes use of a log-periodic pair of driven elements to achieve a passband characteristic and a low value of s.w.r. across the whole 7 MHz band. Elements are mounted on a 42 foot boom, made of 3" diameter tubing. The longest element is about 47 feet. Each element makes use of linear loading, that is, a portion of the element is folded back against itself to conserve length. Tuning straps at the center of each element permit adjustment to be made. Each element has a butt diameter of 1¼ inch, tapering to ½-inch at the tip.

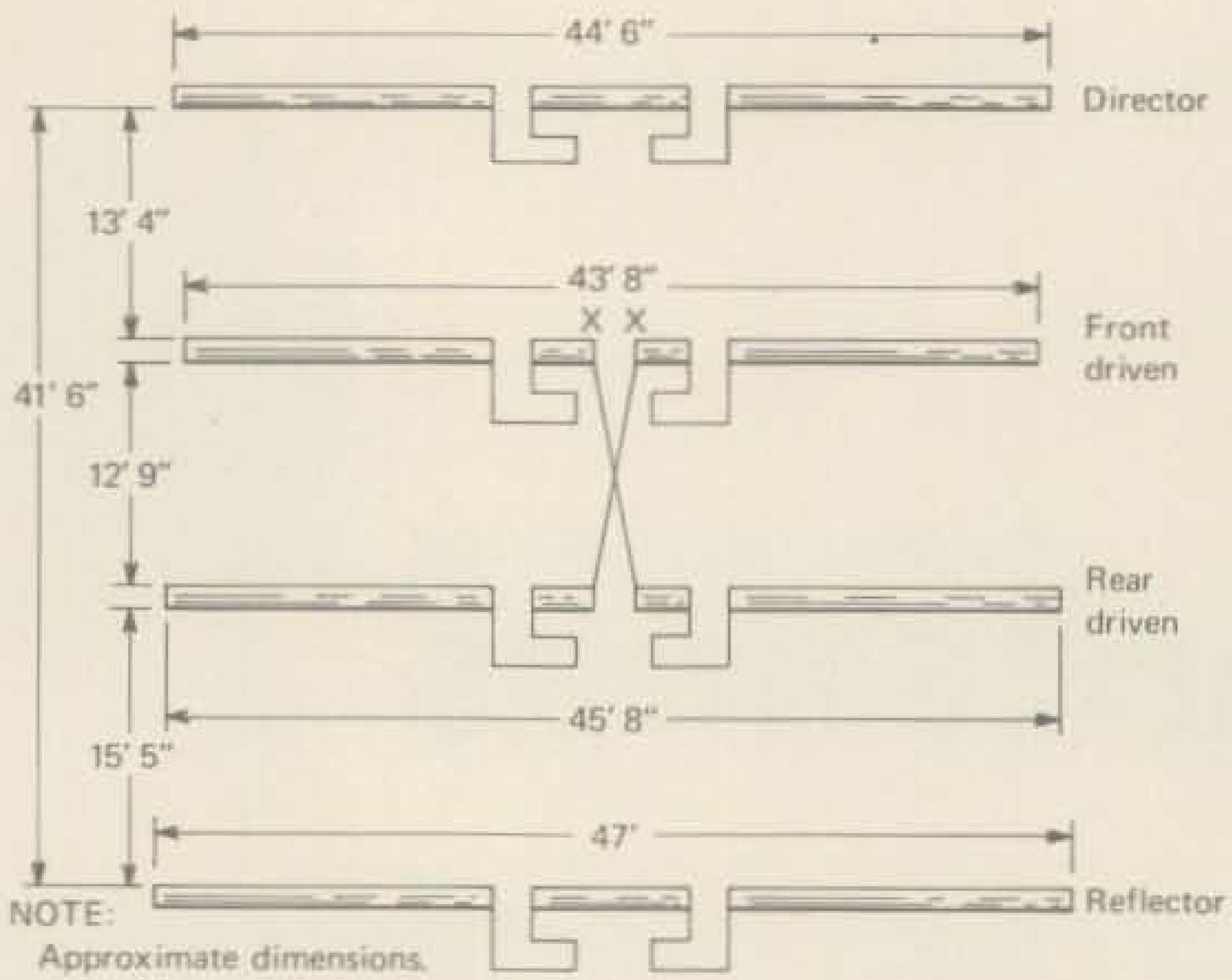


Fig. 2 — Layout of the KLM 40 meter beam. All elements are fixed in length, but the director may be varied a few inches to lower the s.w.r. at either the 7.0 MHz or the 7.3 MHz end of the band. The linear loading sections are made of ⅜-inch diameter tubing mounted alongside the element. A 200 ohm balun is attached to the log-periodic section at points X-X.

"Right," I replied. "This antenna combines good bandwidth with compact, linear loaded elements. Of course, it isn't a small antenna. It's a big one. But it takes a beam antenna of this size and power gain to do the job on 40 meters. I would certainly be interested in reports from other users of the 40 meter KLM antenna, as it is an unusual design, and it certainly seems to perform well."

Pendergast sighed. "How about the little fellow who doesn't have the money, space or a big tower to put up a 40 meter beam? What can he do?"

"Cheer up," I replied. "All is not lost. Plenty of DX can be worked with simple antennas. The April, 1976 issue of *Radio Communication*, the great magazine of the Radio Society of Great Britain, has a description of a simple and effective antenna used for 40 and 160 meters by my good friend, G2RO."

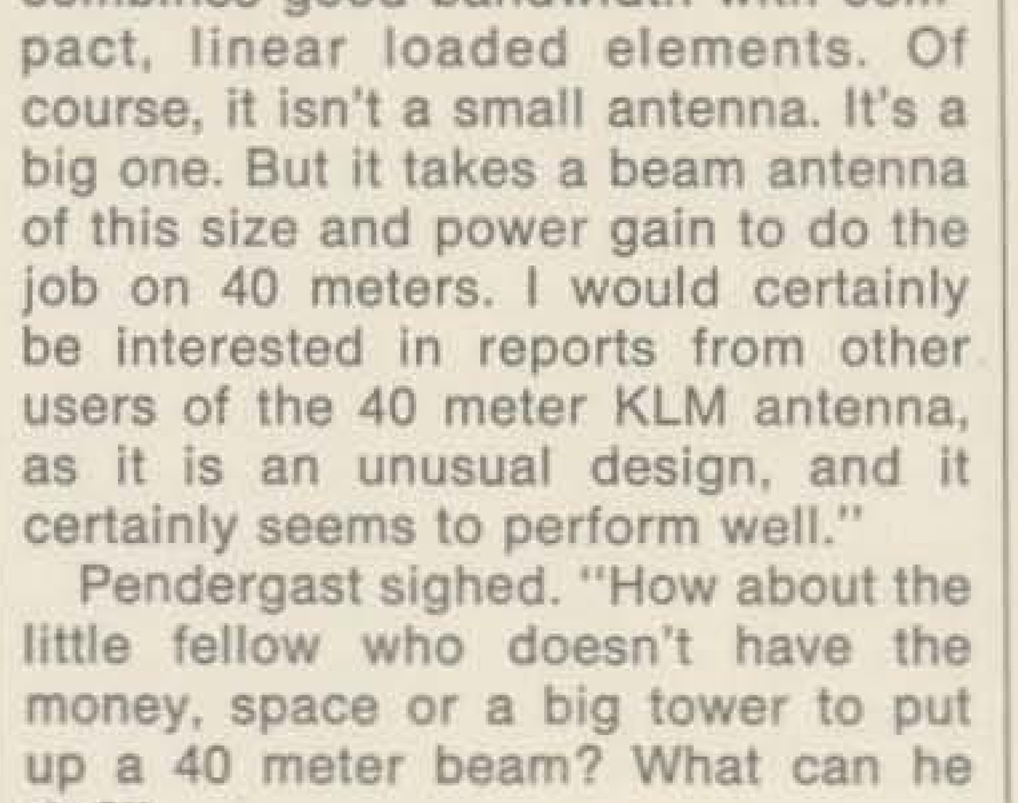


Fig. 3—The s.w.r. curve of the KLM beam when adjusted for low s.w.r. at the 7.0 MHz end of the 40 meter band. S.w.r. remains below 1.4-to-1 across the band, except for the top 30kHz of the phone section. A slight adjustment to the reflector drops the s.w.r. at the high end of the band, and raises it slightly at the low end. This plot was run with the beam 68 feet above the ground.

"Forty and one-sixty. That's an odd combination," observed Pendergast.

"It is," I admitted. "Here's the design (fig. 4). G2RO put up an end-fed wire tahat was 5/4 wavelength long at 7 MHz—that's 165 feet. He worked it against a good ground system. He trimmed the wire length a few inches at a time until he got a satisfactory match across the whole 7 MHz band. He then realized the antenna was slightly longer than one-quarter wavelength for 160 meters. So he inserted a tuning capacitor and series-resonated the wire to 1.8 MHz. It took about 600 pF to do the job. He then found out that the capacitor had a very negligible effect on 40 meters. So he left it in the circuit all the time and ended up with a two-band antenna that is very effective on both 40 and 160 meters."

Pendergast looked at the sketch thoughtfully, then said, "It seems to me that if you cut the length of the antenna in half, you would have a simple antenna that would work well on both 80 and 20 meters."

"That's right," I exclaimed. "A wire about 82'6" long would work on both 80 and 20 meters. And that's not a bad antenna for communication within the United States on both bands! You won't knock 'em dead in a pile-up with this antenna, but it is a solid performer. I would suggest two or more quarter wave radial ground wires, plus a good ground connection for either the 160/40 meter or 80/20 meter antenna."

"Any other dual-band antennas?" asked Pendergast, as he made a quick sketch of the G2RO antenna in his notebook.

"Well, yes," I replied. "I received a note from Jack, W9HJM, about his sloper antenna. He has a 40 foot tower with a TV antenna atop it and he decided to make it into a sloper for 80 meters (fig. 5). He ran out a 65 foot wire to a 12 foot post and fed the wire at the top end with about 75 feet of 50 ohm coaxial line. He grounded the shield of the line to the top of the tower and grounded the base of the metal tower to a 10-foot ground rod, as well as to several copper water pipes. Interestingly enough, he found out that the antenna worked well on 10 meters in addition to good performance on 80 meters. Here are his s.w.r. measurements on the two bands (fig. 6)."

"Well, I'll be dipped," said Pendergast. "That's the first time I've ever heard of the sloper antenna working on two bands!"

"Yep," I replied. "W9HJM works all over the country when 10 meters is open, so it looks as if he has a "freebie" with his simple 80 meter sloper!"

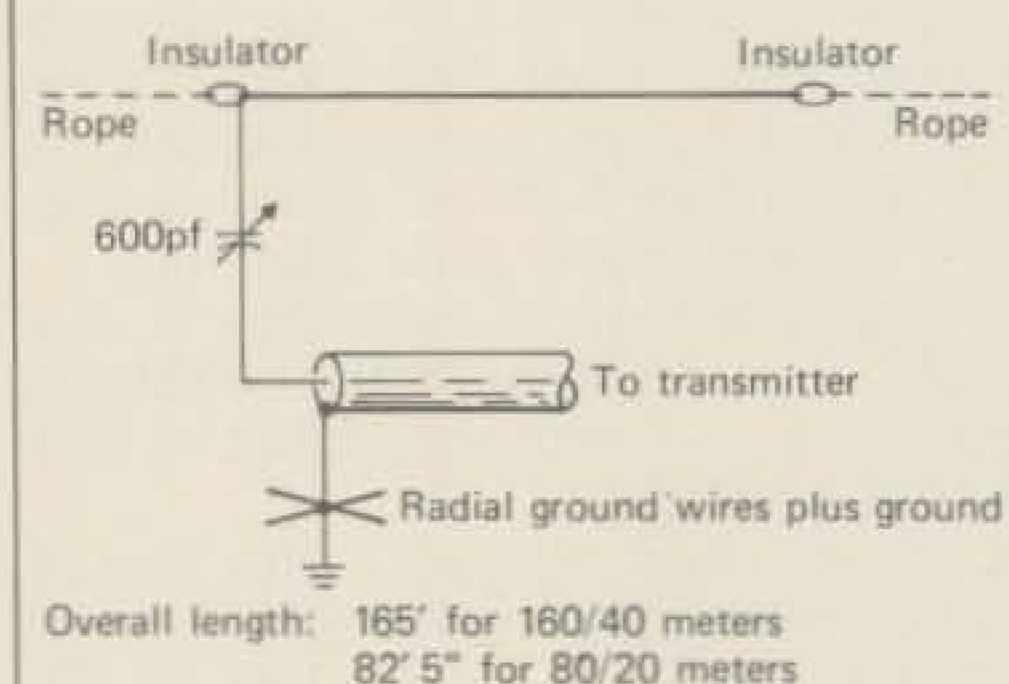


Fig. 4—The G2RO two-band end-fed antenna. This antenna is designed for either 160/40 meter or 80/20 meter operation. The antenna length is trimmed for lowest s.w.r. on the high band with the capacitor shorted out. It is then tuned for lowest s.w.r. on the low band by means of the capacitor. A good ground connection should be used to reduce losses to a minimum.

"I guess we haven't heard the last of the sloper," said my friend. More and more fellows are experimenting with this simple antenna and it produces surprises every day."

Pendergast paused, then he said, "I wonder if W9HJM's location had anything to do wtih his results?"

"I don't know," I replied. "But location seems to have a lot to do with it. Some guys have good locations, and some have bad ones. And I still really don't know how to pick the good one from the bad one!"

"Look at this," I continued. "Here are signal strength plots made by the Bell Telephone Laboratories in 1932 (fig. 7). This is part of a study BTL made to determine the best location for a shore station in ship-to-shore radiotelephone service. Signals from a ship were recorded at various land locations while the ship cruised about, out to as far as 2500 miles from the shore station. The results

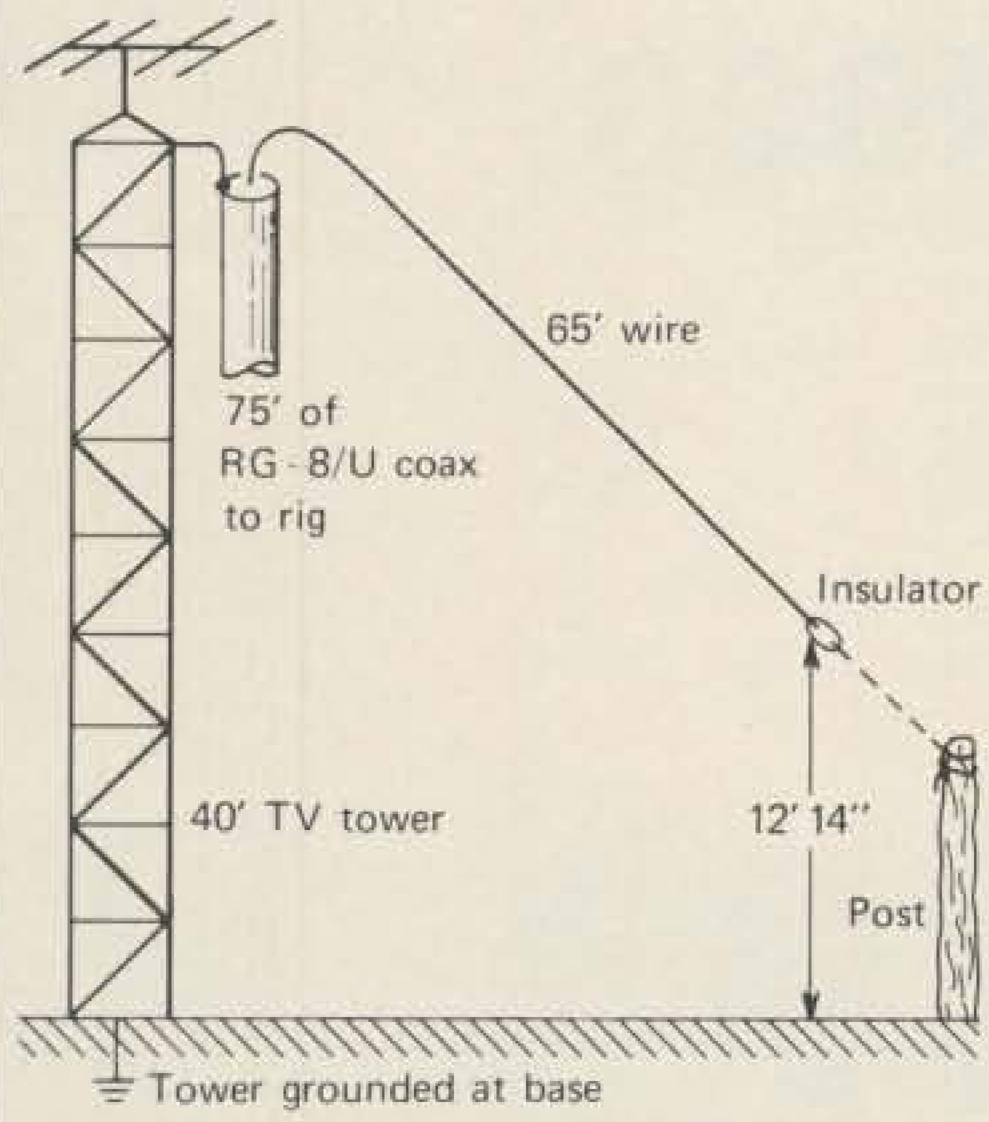


Fig. 5—The W9HJM Sloper antenna for 80 meters is made up of a TV tower, with the sloper wire running off to a nearby post. It was found by W9HJM that the sloper works equally well on 10 meters as it does on 80 meters!

strongly indicated that for an over-water path, the closer the shore station was to the water, the better were the results. Measurements were made at 66 meters and 33 meters, for both day and night conditions. The blunt statement was made that "attenuation of 8 dB to 12 dB is observed at a distance of one mile inland for both 33 and 66 meter transmission." That seems to indicate that a location near the water is to be preferred for over-water transmission.

"The whole subject is written up in the *Proceedings of the IRE* for January, 1932 under the title, *"Effect of Shore Station Location Upon Signals,"* by R.A. Heising, of the *Bell Telephone Laboratories."*

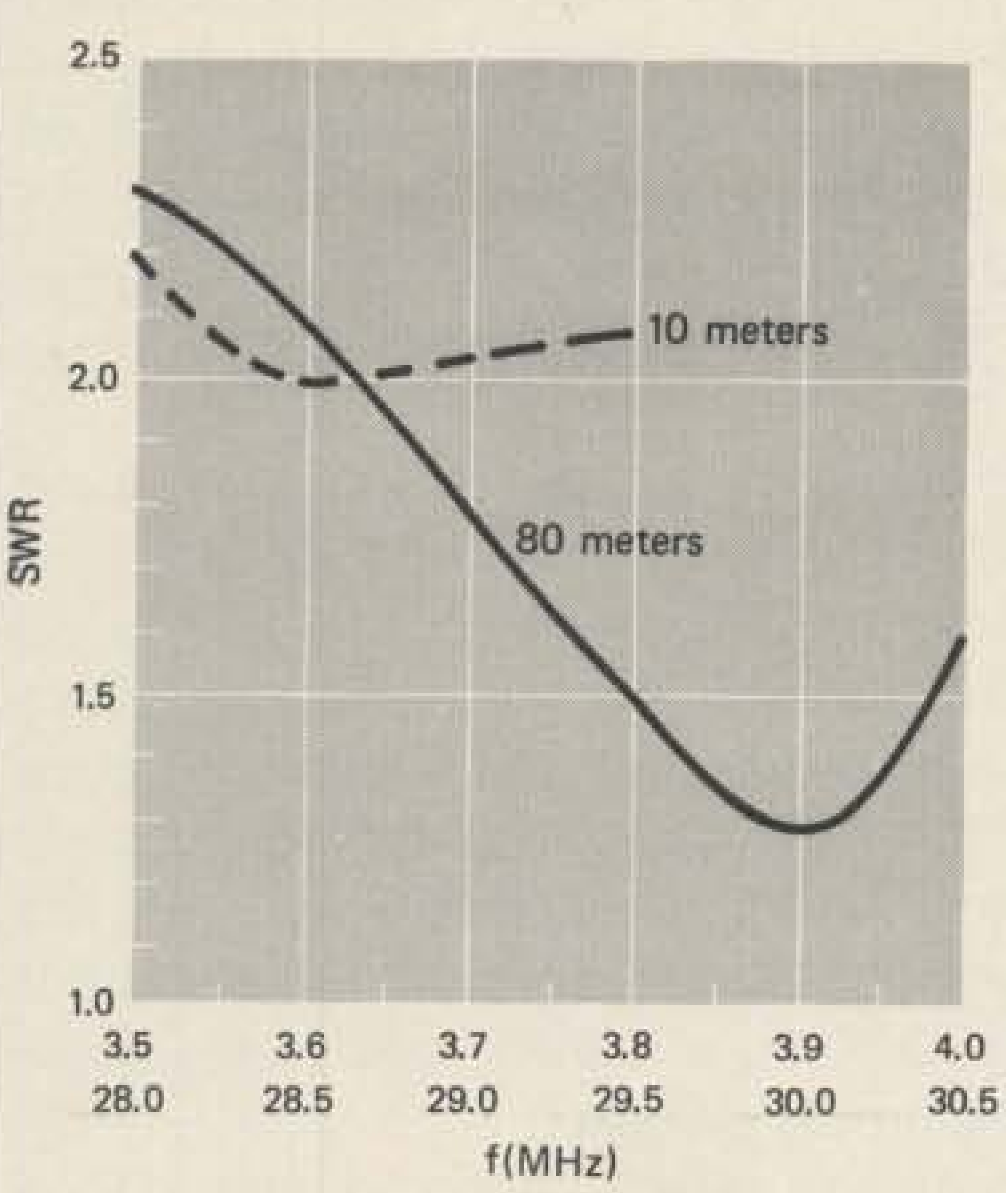


Fig. 6—The s.w.r. plot for 80 and 10 meters for the W9HJM sloper antenna. The sloper is resonant at 3.9 MHz on 80 meters and at 28.6 MHz. on 10 meters.

Pendergast said, "This is one of the things that makes amateur radio so interesting. There's still mysteries in long distance transmission and antennas and all the answers aren't known. I guess station location is one of the big unknowns, because you can't account for the exceptional results some amateurs seem to have from rather mediocre locations."

"Yes," I replied. "The ionosphere is a great leveller of signals. Working DX, in the long run, teaches you humility, if nothing else."

"Speaking of humility," I continued. "Here's a little problem for you. Have you ever heard of the SP5AY antenna? No? Well, I read about it in an issue of *CQ-Ham Radio,* the Japanese publication. Now since my Japanese and my Polish are on a par with each other—namely, zero—all I could go by was the drawing. Look at it. (fig. 8). The SP5AY antenna, I gather, is an all-band antenna in the sense it is supposed to work from 3.5 to 29 MHz. It consists of a horizontal wire 54'4" long, fed at one end, plus four radials, each 16'6" long. The radials run down at a 45 degree angle from the antenna."

Pendergast squinted at the drawing for a long time, then said, "I don't see how in the world it functions."

"Neither do I," I admitted. "According to the article, the s.w.r. averages 1.5-to-1 on the 80 meter band, 1.4-to-1 on the 40 meter band, and 1.5-to-1 on the 20, 15 and 10 meter bands."

Pendergast looked at the drawing in the Japanese magazine.

"It all looks terribly simple," he admitted. "The only thing I notice is that the mounting arrangement for the radial wires places a certain amount of capacitance across the end of the coaxial line. I would guess about 20 pF. I wonder if that has anything to do with the system?"

"I don't know," I replied. "I can't read Japanese, so the whole thing is Greek to me, as the saying goes."

"Ask your readers," exclaimed Pendergast. *"Somebody* out there must know about the SP5AY antenna! I'd like to know how the darn thing works, if it does."

"Agreed," I said. "I'll donate one of my antenna handbooks to any reader who knows something more about this interesting antenna. Does it work? Is this the correct information? Any multi-band antenna is interesting, and I enjoy mysteries. And the SP5AY antenna, at this stage of the game is a *real* mystery.

For the sake of the record, the article about this antenna was in the June, 1974 issue of *CQ-ham radio,* so the antenna has been around for a few years."

"Any closing remarks?", asked Pendergast, as he prepared to close down his station.

"One more thing", I replied. "I got a quick note from Joe, WA7GSM, who just got an Atlas 215 for mobile work. He had an old Webster Band-Spanner mobile antenna and the Atlas didn't want to load the whip, even when the Atlas matching transformer was used. So Joe bought a 102-inch CB whip and machined the bottom end to fit into the spring and fitting of the lower end of the original whip. Then, he slipped the whole works into the Webster Band-Spanner base coil. Finally, he placed a 1000 pF capacitor from the base of the whip to the body of the car. By adjusting the length of the whip, he

(Continued on page 70)

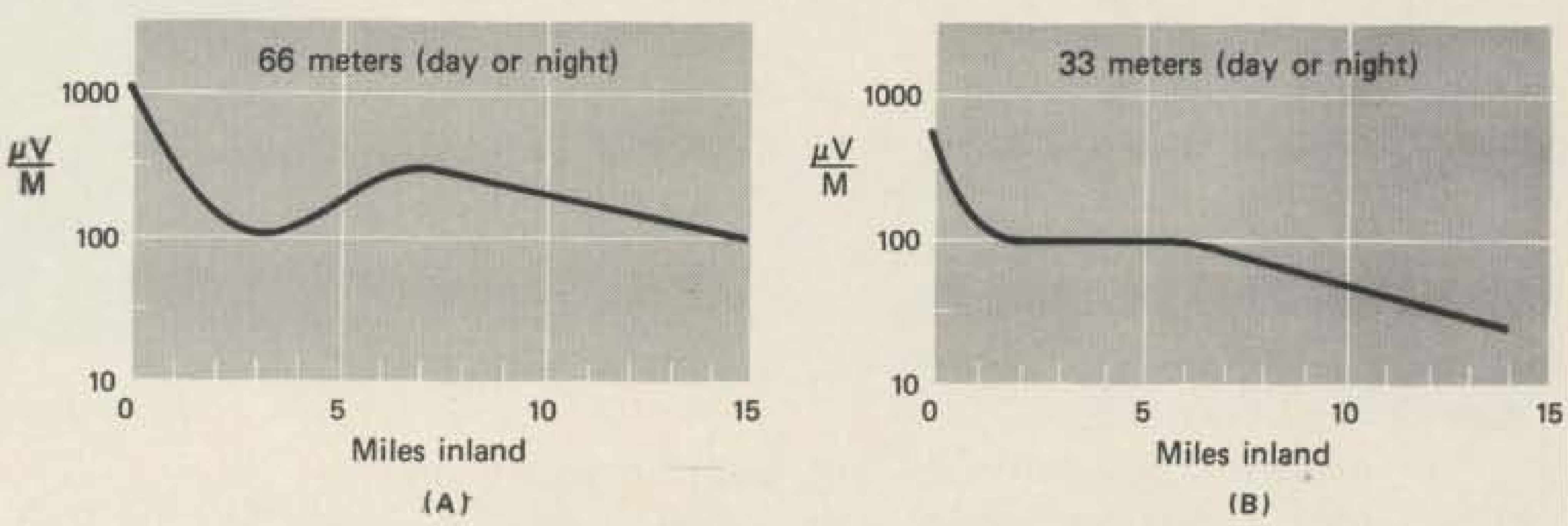


Fig. 7—The plot of many readings taken over a period of time on 66 meters (A) and 33 meters (B) for a ship-to-shore radio path. Signals were attenuated 8 dB to 12dB only one mile inland at both frequencies. Location near the water is to be preferred for over-water transmission.

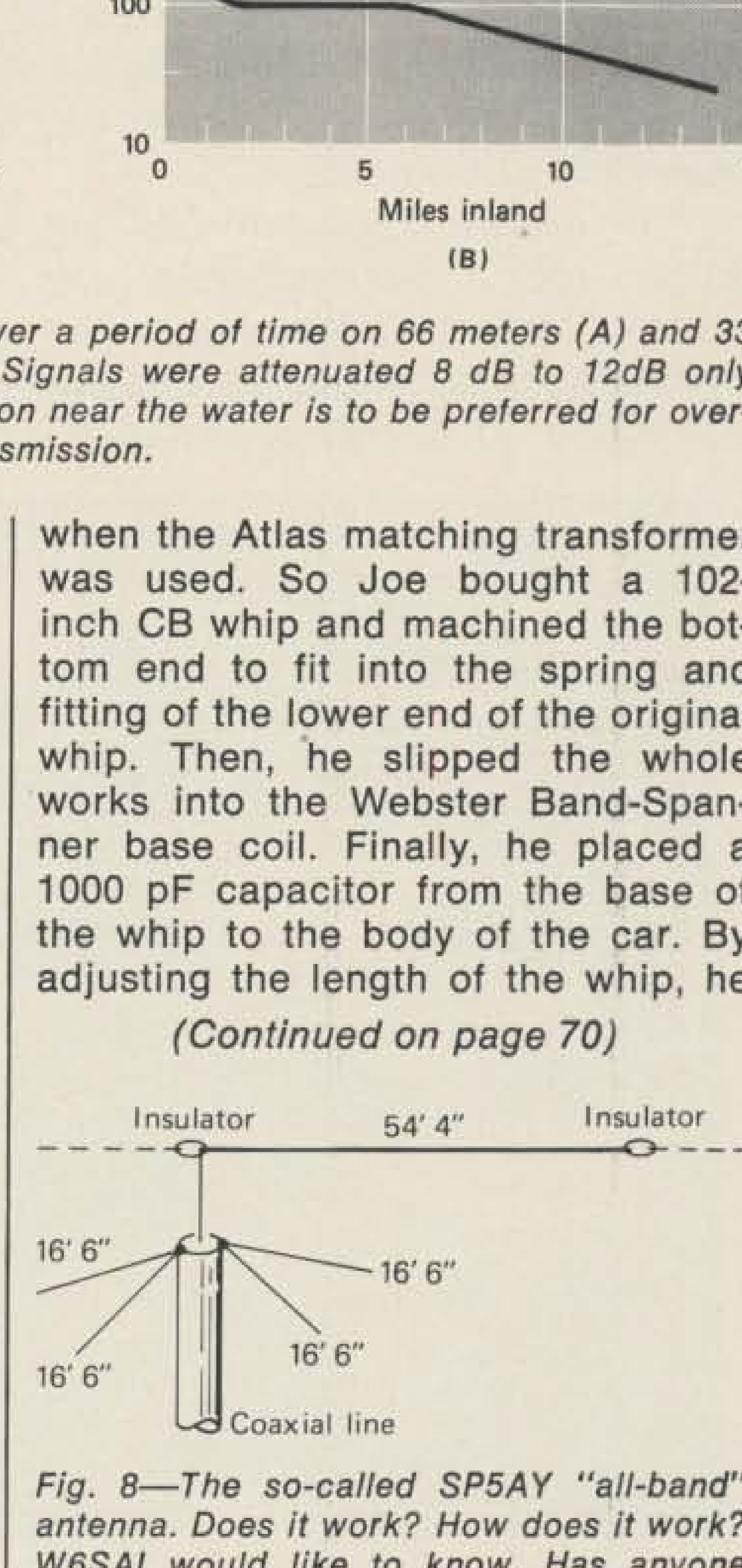


Fig. 8—The so-called SP5AY "all-band" antenna. Does it work? How does it work? W6SAI would like to know. Has anyone tried this unusual antenna?

Where Are You Now?

The following people have been issued certificates for various contests, however due to incorrect addresses we have been unable to send them. If you know the whereabouts of any of these people please drop a line to CQ Magazine, 14 Vanderventer Ave. Port Washington, N.Y. 11050.

WWDX - 1967

KL7FRY, SVØWP, HA2MM, ZD5M

WWDX - 1968

DM4SLG, 8P6CV, VU2DKZ, DM2BOG DL4FB, 2D8Z, OM1ADP, VE2BV

WWDX - 1969

I1NU, OX5BLV, KA2RH, PAØXPQ FG7XX, CR6GO

WWDX -1971

WØNQQ, KR6AY, WA3HGV, W7UI, FY0NA, VK6WO, WB2RLK/VE1

WWDX -1972

K8WWU

WW Side Band DX - 1967

GM5ACE

WW Side Band DX - 1969

GD3AIM, HS3RT, VK6HJ, OD2ABV KR6KN, VK1GD

WW Side Band DX - 1970

DM6AO, XW8DX

WW WPX - 1972

OX5BA

160 Meter Contest - 1973

8P6DR

Awards *(from page 61)*

issued for any future QSOs with WB6CKU, for USA-CA.

Sorry to report the loss of two more County Hunters:

J. F. Wemmlinger, W2JGY.

James Farris, Jr., WA4MGC, *All Counties*, #90, 12-22-72, and Story/Foto January 1975 *CQ*.

Also sad to report the loss of an old friend, Chas. Porter, K2ER, ex-2OA (back in the early 1920s and before that), ex K6JT and K4OA. Chas had been associated with Loew Theatres/MGM Pictures, Col. in the OSS, and also with NBC on the west coast before he retired some years ago.

How was your month?

73, Ed., W2GT.

Math's Notes *(from page 50)*

izes" the inverter and the two capacitors are used to trim the crystal. Increasing C_1 pulls the frequency down while decreasing C_2 pulls it up. The other two inverters simply shape up the output so it will drive other circuitry.

This circuit would be the ideal starting point for a marker generator.

73, Irwin, WA2NDM

Novice *(from page 48)*

and blow the written test will eventually be given credit for the code, if they pass the written test within a given amount of time. . . . **Charles McDonald, WN3FYM, AK3YBM,** 312 Penna Ave., Dowingtown, Pa. 19335, needs three states for his WAS (worked all states) certificate. His country total is 37, including ZF1AG, who is Art, K8SWW, at home and K4BR/VP9. He worked ZF1AG on both c.w. and phone (Art on phone), and K4BR/VP9 on both 80 and 40 meters. . . . The Maple Hills HS Amateur Radio Club, Castleton, N.Y. (WB2YCR) graduated four Novices from its spring Novice course conducted by John, WA2UON, with more expected before the summer is over.

All readers are invited to send "News And Views," pictures, and suggestions to your *column*, no matter what the class of their licenses. Address all mail to: Herbert S. Brier, W9EGQ, Novice Editor, "CQ Magazine," 409 S. 14th St., Chesterton, Indiana 46304.

73, Herb, W9EGQ

DX *(from page 60)*

the old style IRCs will no longer be good after 1976. It seems that there was a possible conflict with ITU regulations and when the matter was taken up with L'Enfant Plaza Headquarters of the Postal Service that a change of mind ensued.

A Bulgarian oceanographic expedition is expected to be drifting towards Polynesia until September and may be heard signing LZOG/mm. Apparently they are retracing the path of the Kon Tiki and they have a low-power transceiver with them. They are expected to operate at 14073 kHz or 14273 kHz around 1830Z. LZ1KBG has asked for reports from anyone working them as this is the only way they can determine how the effort is going. WN3SHX operated from St. Brandon in April . . . the whole operation was only a couple of hours under difficult conditions. BQ6AB is reported as heading back to Sri Lanka and with the VS9-stations going QRT, the activity from the Maldives may be scarce. AI4ARU was at the Region II IARU meeting and QSLs to W4WYR. During the Spring the DXAC have been mulling over some proposals to change the DXCC criteria . . . like reducing that criteria which calls for 225 miles down to 150 miles. This was not the one in question for Okino Tori Shima, that was Rule 2B which called for 500 miles of separation.

Andre Saunders, ex-5Z4KL, is teaching school at Cockermouth in Cumbria. He heads the Science Department. There has been a report that KP6-Palmyra is being leased by a chemical company which may pretty well seal up the lagoon there. Tihs may bring some regular operation from KP6 as a side benefit.

QSL Information

A6XR—Via G4CHP
EP2OD—Via K4OD
FK0KG—Via YASME
KC7LBH—Via WA7OBH
N1ITU—Via W1GNC
NE1ITU—Via ARRL
NZ1ITU—Via K1HRV
N2ITU—Via WA2EAH
N3ITU—Via W3DOS
N4ISC—Via W4IMP
NQ4ITU—Via WB4FDT
NU4ITU—Via K4ZA
NS4ITU—Via WB4FLW
N6ITU—Via K6ILM
NA6ITU—Via W6UFJ
NV6ITU—Via WA6TAX
NE6ITU—Via WA6PDE
NK8ITU—Via W8RSW
N8MI—Via K8IDE
N9ITU—Via K9GSC
VP5SF—Via WB4SHB
VE1APY/SU—Via VE1APY
VR3AH—Via K2BT
KR3AK—Via KH6AHZ
VU2ACD—Via WB7ACD
WU4ITU—Via K4YFQ
WV8ITU—Via W8BT
WI9ANG—Via WA9DZL
XJ3ZZ/1—Via VE3BMV
UN1FI1—Via VE3BWY
YJ8KG—Via YASME
5B4BK—Via OE2SJL
7J1RL—Via JARL
9Y4AC—Via VE7BZC
VP5MD—Via Rt. 1, Box 365B, Valrico, Fla. 33594

Antennas *(from page 37)*

was able to achieve unity s.w.r. at any point in either the 80 or 40 meter bands, and signal reports were excellent.

"Joe mounted the whip on the left front fender of his 1970 4 ×4 Chevy pickup truck. He says he hasn't brushed the whip on any low overpasses yet!"

"It doesn't sound like a thing of beauty", observed Pendergast, "But I bet it works. Adding several feet to a loaded 80 or 40 meter whip often works wonders". ■

WILLIAM I. ORR, W6SAI, ON

Antennas

"Congratulate me", said Pendergast with a happy smile as he handed me a sheet of yellow graph paper. "I've just designed an 80 meter antenna for my station".

"Congratulations!", I responded heartily. "Tell me about it. Have you re-invented the wheel, or is this something that will change the course of antenna history?"

Pendergast laughed easily as he sat down beside me. "I guess its a case of re-inventing the wheel. Anyway, you know the problem I have—not enough yard space for an 80 meter antenna. Its the old story—I've fellows have had with the *sloper* antenna, so I decided to make my dipole into a sloper. I cut the dipole for 3800 kHz, so it was 122 feet, overall. Half of the dipole, or 61 feet of wire, just fitted in between my tower and the TV mast next to the roof of the house.

"The other half of the dipole I bent downwards, running it off at an angle to the tower, down to about six feet above the ground. I then tied it off to the wood fence and ran it along the fence. At the far end, it was about three feet off the ground".

I said nothing, so Pendergast took tacts . . . nothing spectacular, because it has only been up for a few days. But plenty of stations out to 1200 miles or thereabouts, with good reports. And I'm only using my transceiver barefoot".

"The dipole is a very forgiving antenna", I remarked. "This shows that you can actually use half of it as a sort of radial ground wire, and the other half will do the job for you. Pendergast, I like your style. That's a good antenna, and probably has a lot less loss than an equivalent Marconi antenna".

Pendergast blushed with pleasure.

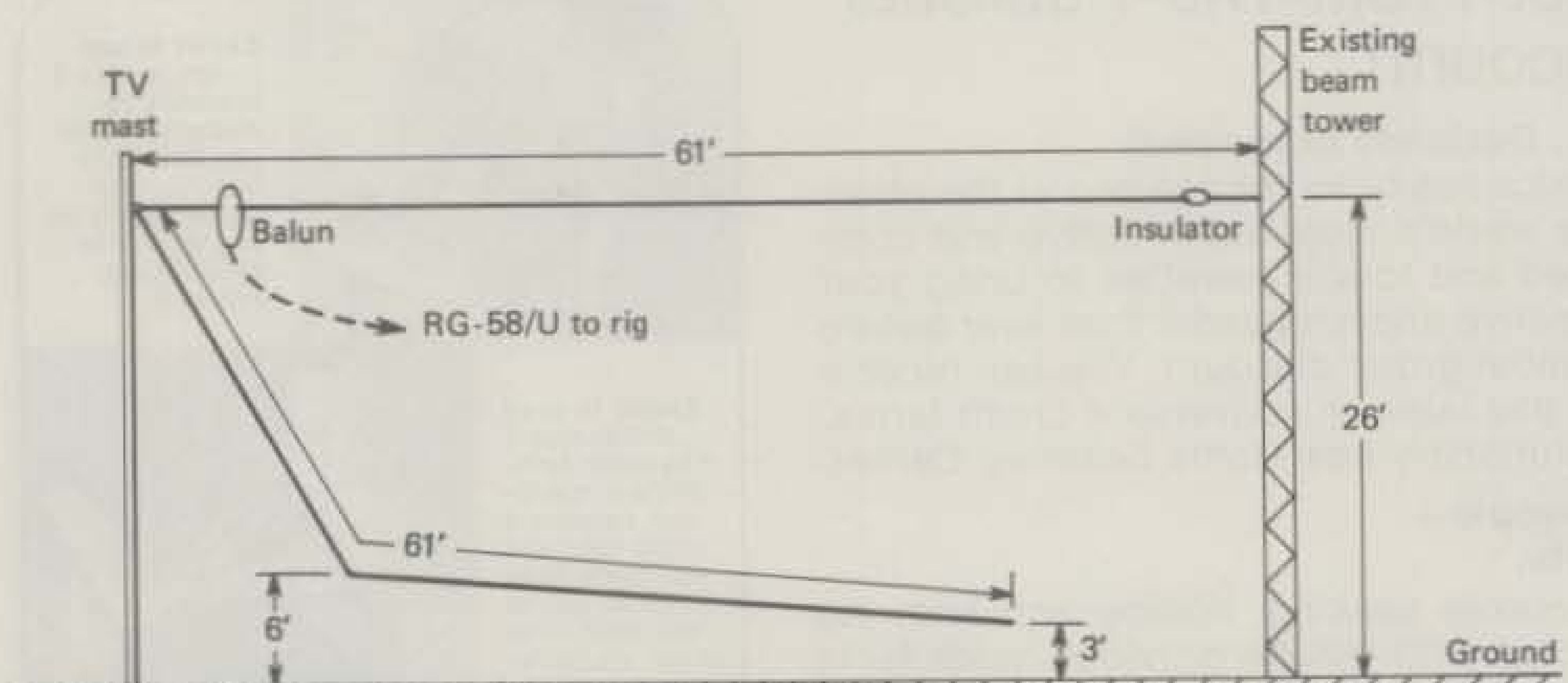


Fig. 1—The "Pendergast" version of the sloper antenna for 80 meters. The dipole is 122 feet overall, cut for 3800 kHz. One 61 foot section is horizontal and about 26 feet above ground. The other portion of the dipole serves as a "radial wire" and runs down towards the ground, at an angle from the mast. About six feet above the ground, it is tied off to a wood fence and runs along the fence for the remainder of the length. The dipole is fed with a 1-to-1 balun and a random length of 50 ohm coax line.

tried end-fed Marconi antennas, verticals and never really had much luck, so I decided to put up a full-size dipole".

"On your lot? You must be kidding. You just don't have the room to run it out".

"Agreed", replied my friend. "The longest stretch I have is just about sixty three feet. My tower for the triband beam is in one corner of the back yard, and all I have is a run of a little over sixty feet to the house. So guess what I did?"

"Tell me!", I pleaded.

Pendergast turned to his drawing (fig. 1). "I remember the luck some a big breath and continued. "I figured that the high portion of the dipole would act as a radiator and maybe the folded-down section would act as a radiator and maybe the folded-down section would act as a sort of radial wire. Then I fed the antenna with a balun in the normal manner. The top wire was just about 26 feet above ground."

"Well, how did it work?", I asked, looking closely at the drawing.

"Great!", enthused my friend." Look at the s.w.r. plot (fig. 2). The bandwidth is somewhat less than that of a normal dipole, but the antenna provides over 100 kHz bandwidth between the 2-to-1 s.w.r. points. And I've had plenty of con-

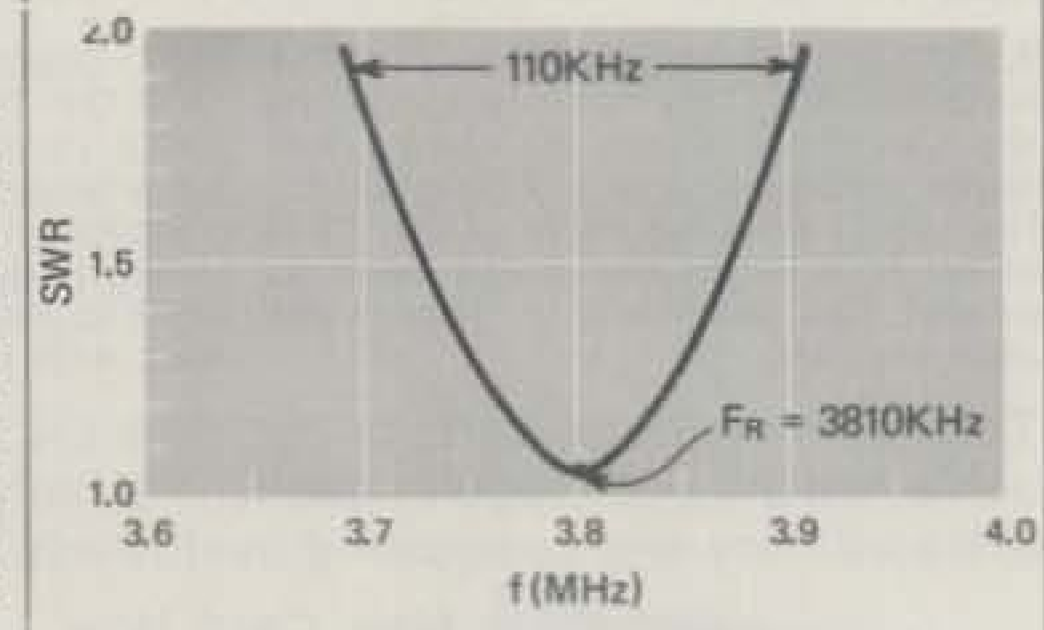


Fig. 2—The s.w.r. plot of the dipole of fig. 1. An operational bandwidth of over 100 kHz between the 2-to-1 s.w.r. points is achieved about the design frequency of 3.8 MHz. Bandwidth would probably be better if the "radial wire" was run off in the opposite direction to the flat top. Antenna also works well on 10 meters, providing an s.w.r. of less than 1.4-to-1 from 28.5 MHz to 29.0 MHz.

*48 Campbell Lane, Menlo Park, CA 94025.

"And guess what? It works on 10 meters as a center-fed long wire! The s.w.r. is below 1.4-to-1 from 28.5 MHz to 29.0 MHz. And I've worked all over the U.S. of A. on sporadic-E skip with this antenna. Two bands for the price of one!"

"Yes", I agreed. "The antenna works as a seven half-wavelengths wire on 10 meters. God knows what your radiation pattern looks like; it's probably a hash of both horizontal and vertical polarization. The point is, you have a simple, inexpensive and compact antenna that does the job on both 80 and 10 meters. I would imagine that you can vary the s.w.r. plot around by moving the lower wire with respect to ground. Some time you might try running the lower wire away from the upper one, just to see what happens. I think if you did that, you might improve the s.w.r. bandwidth on 80 meters".

Pendergast breathed a happy sigh and nodded his head. "Perhaps I'll do that next weekend. But things are working so well, it might be a good idea to leave well-enough alone".

"You aren't the only backyard experimenter", I remarked. "Look at this photo of Dave, W3LSG. He's got a four element, triband Quad on a crank-up tower. This is the *sixth* Quad he's built. Notice how he works on it. He drops the crank-up tower down and then climbs up to adjust the elements on a guyed extension ladder (fig. 3). That's a fine idea. He can clip onto the ladder with his safety belt and use both arms to work on the Quad. That looks like the safe and smart way of experimenting on one of these monster antennas".

"It is a good idea", agreed Pendergast. "I am a coward when I'm more than 20 feet in the air".

"And here are two more good antenna ideas from that avid experimenter, Mike, WA3GJA. He suggests using a *Hustler* mobile antenna as the top loading device to make a vertical antenna for 80 and 40 meters (fig. 4). The basic antenna is a 40 meter ground plane made of aluminum TV mast sections. It has four 40 meter radials at the base, strung out over the grass. It also has four 80 meter radials, plus a six foot ground rod.

"At the top of the 40 meter radiator the 80 meter *Hustler* resonator is mounted on a ⅜ × 24 stud. The mobile whip above the resonator is adjusted to provide resonance at the desired frequency in the 80 meter band."

"Isn't this antenna quite sharp on 80 meters?", asked Pendergast.

"Probably", I replied. "It should be broad enough to cover the whole 40 meter band, but I would think that the passband on 80 meters is limited to about 50 kHz. That's not bad, however, for an antenna of this size".

"What's the other antenna?", asked Pendergast, as he made notes in his ever-present lab notebook.

"Mike's other antenna is also designed around a slip-up TV mast. It is a double inverted-V for 80 and 40 meters. The mast serves as a support for the center of the antenna and the wires of the inverted-Vs serve as guy wires for the mast. The inverted-V dipoles are connected in parallel at the top feed point and fed with a single 50 ohm transmission line of RG-58/U cable. Since both Vs are full-size dipoles, bandwidth is good on both 40 and 80 meters."

"How about a tri-band antenna that's simple and easy to erect?", asked my friend. "Something that takes up a minimum of space?"

"Well, my old friend WA7LRU came up with an interesting antenna", I replied. "Bill wanted a compact triband antenna and he designed the

Fig. 3—Here's how Dave, W3LSG works on his four element Quad. The tower retracts to the 20 foot level and Dave makes his adjustments from the top of a guyed 20 foot extension ladder. He clips onto the ladder with a safety belt so he can use both arms to work on the antenna.

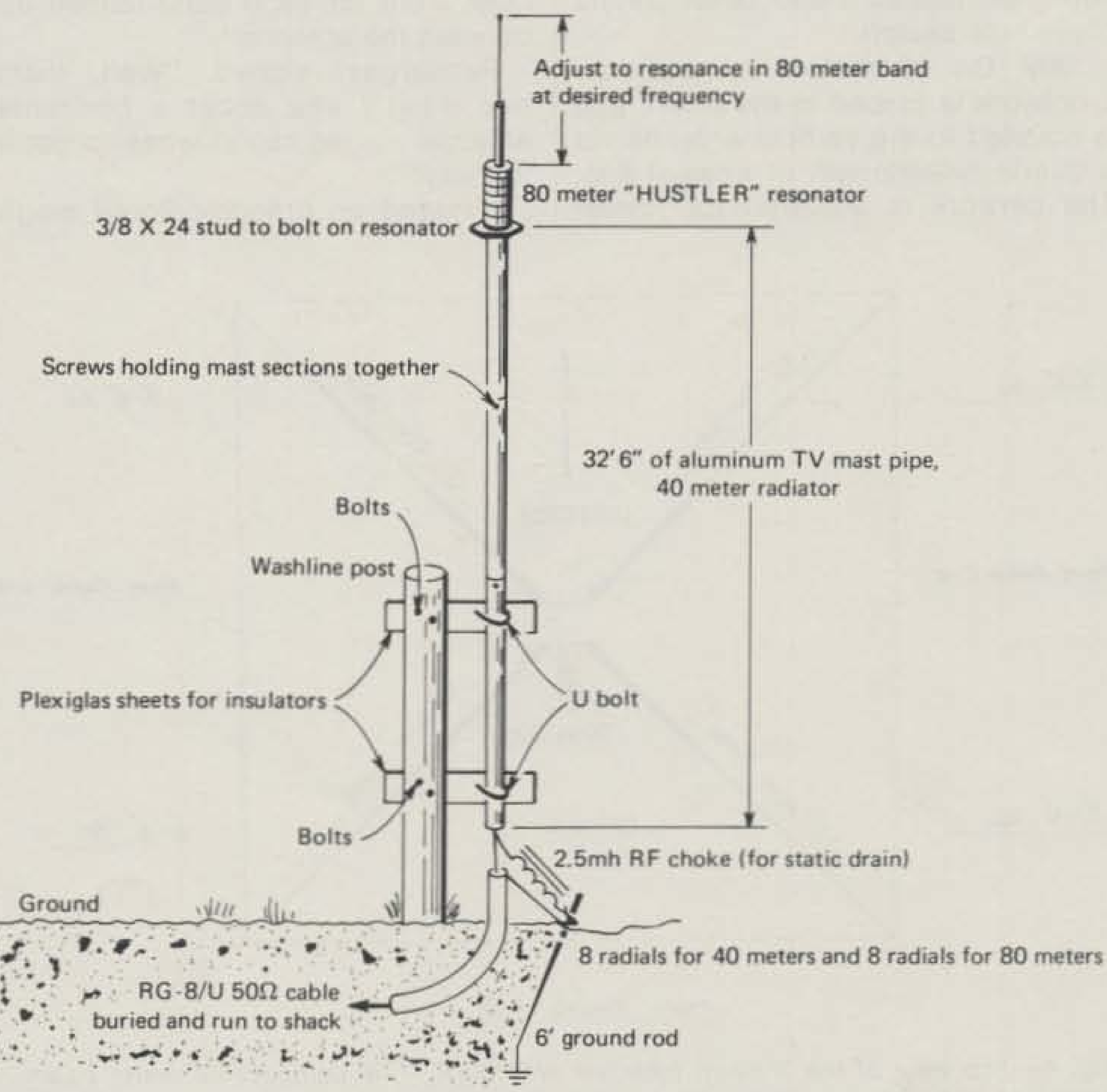


Fig. 4—The WA3GJA vertical antenna for 40 and 80 meters is made of a Hustler mobile whip mounted atop a 40 meter ground plane. The resonator and top section are adjusted for resonance at the operating frequency in the 80 meter band. Separate radials for 80 and 40 meters, plus a ground rod, are placed at the base of the vertical. An r.f. choke is placed across the coaxial line at the base of the antenna for a static drain.

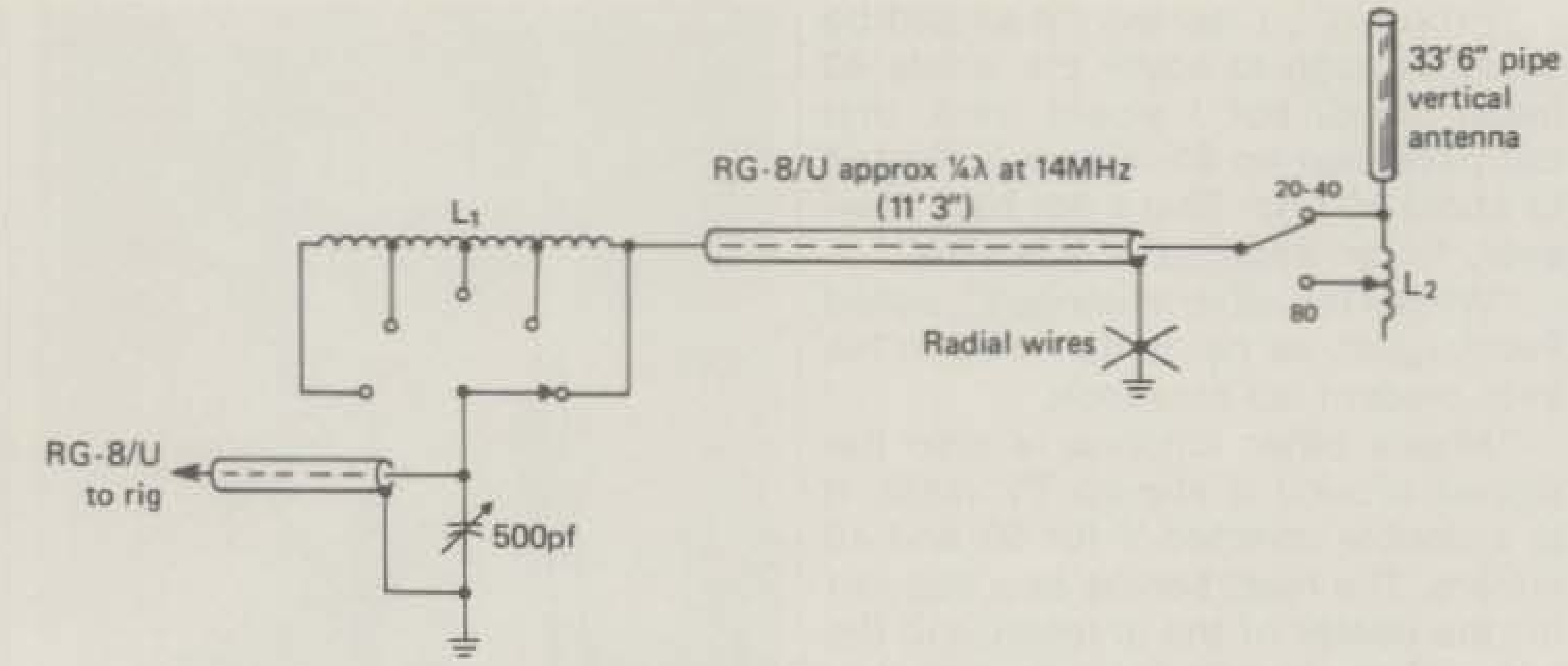


Fig. 5—The 80-40-20 meter vertical antenna of WA7LRU. Antenna acts as a ground plane on 40 meters, with L_2 out of the circuit. On 80 meters, antenna is base loaded by coil L_1. On 20 meters, antenna is a half-wave vertical, fed through a quarter-wave matching transformer made of 50 ohm line. Simple L-network matches transformer to 50 ohm line. Network is in the shack and the loading coil is at the base of the antenna. Coils are surplus roller coils and capacitor is double spaced. Radials for the three bands are placed under the antenna.

one shown in fig. 5. It consists of a 34 foot self-supporting vertical made of aluminum tubing. It has radials for 80, 40 and 20 meters at the base—the more radials, the better.

"On 40 meters, the antenna functions as a simple ground plane. On 80 meters, a base loading coil is used to resonate the system to the desired frequency. Bandwidth on 80 meters, of course, is rather narrow—about 25kHz. However, the base loading coil is adjustable, so the antenna can be resonated anywhere in the 80 meter band.

"Well, how about 20 meter operation", demanded Pendergast as he copied the sketch.

"Ah! On 20 meters an auxiliary L-network is placed in the shack and is coupled to the vertical antenna via a quarter-wavelength of coaxial line. The network is adjusted for lowest s.w.r. on the transmission line to the equipment. The line running from the network to the antenna, of course, has quite a high s.w.r. on it—it acts as an impedance transformer. And it does the job.

"Bill has the loading coil switch at the base of the antenna connected to a long extension shaft that pierces the shack wall, so he can switch between the three bands without leaving his operating position.

"And don't forget, with this vertical antenna, or any other vertical, part of the secret of success is to use plenty of radial wires. Bill has at least eight for each band fanned out beneath the antenna".

Pendergast sighed. "Well, that's one thing I *like* about a horizontal antenna . . . no radial wires to get in the way!"

I tossed an orange-colored magazine at my friend. "Say, if you like horizontal antennas, you'll love the *X-Beam* designed by VK2SK and described in the February, 1976 issue of *amateur radio*, the publication of the *Wireless Institute of Australia*. This is a compact, 2 element 20 meter beam that fits within a square less than nineteen feet on a side. Fig. 6 is a top view of the beam. This is a boomless design and, according to VK2SK, the power gain compares favorably with the usual tri-band 3 element beam. You can see why he calls it the X-beam. A driven element and director are used with both elements affixed to a common center piece by means of insulating clamps.

"Each element is split in half at the center to form four arms, the length of each arm being 13 feet. VK2SK suggests the use of ¾-inch, ⅝-inch and ½-inch tubing to make up the arms. The arms droop about a foot at the tips unless a vertical center post is used, with nylon fishing line stays out to the element tips to take up the sag.

"Since the antenna elements are only 26 feet long, it is necessary to add wire "tails" to the element tips to bring them to the proper length. The tails are made up of #24 copper wire and are tied back upon each other by nylon fishing line. Finally, the director element is jumpered at the center and the driven element is fed at the center with a 50 ohm coaxial line. VK2SK passed the line down the inside of his steel mast and brought it out at the base. He concluded that no balun was needed at the antenna end of the line, since the line was shielded by the mast.

"The length of the tails is relative to wire size and the length given applies only to #24 wire. Changing wire size means that the tails must be retrimmed for best performance."

"How do you tune the X-Beam?", asked my friend.

"According to VK2SK, the tails on the director are adjusted for best front-to-back ratio and the tails on the driven element are adjusted for

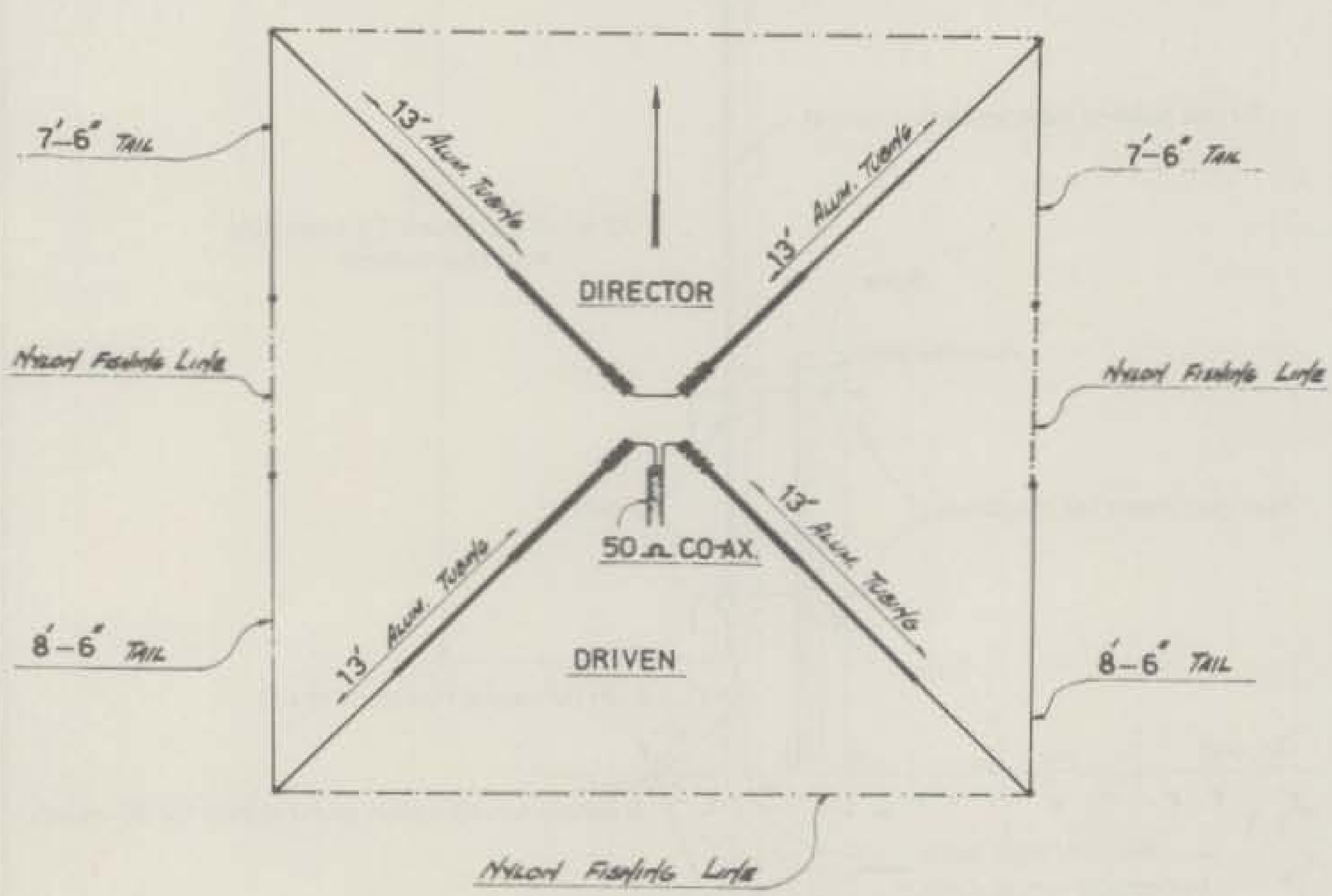


Fig. 6—Top view of the X-beam installed at VK2SK. This compact 20 meter beam is boomless, the elements being supported at the center on an insulated plate. Each arm is 13 feet long. The director sections are connected together at the center, and the driven element is split and fed with a 50 ohm coaxial line. To achieve resonance, wire tops are added to the ends of the element to bring them to the proper length. The tips (or "tails") are folded back and tied to form a square. Nylon line is used to connect the tips together. (Drawing courtesy of amateur radio, *the publication of the Wireless Institute of Australia).*

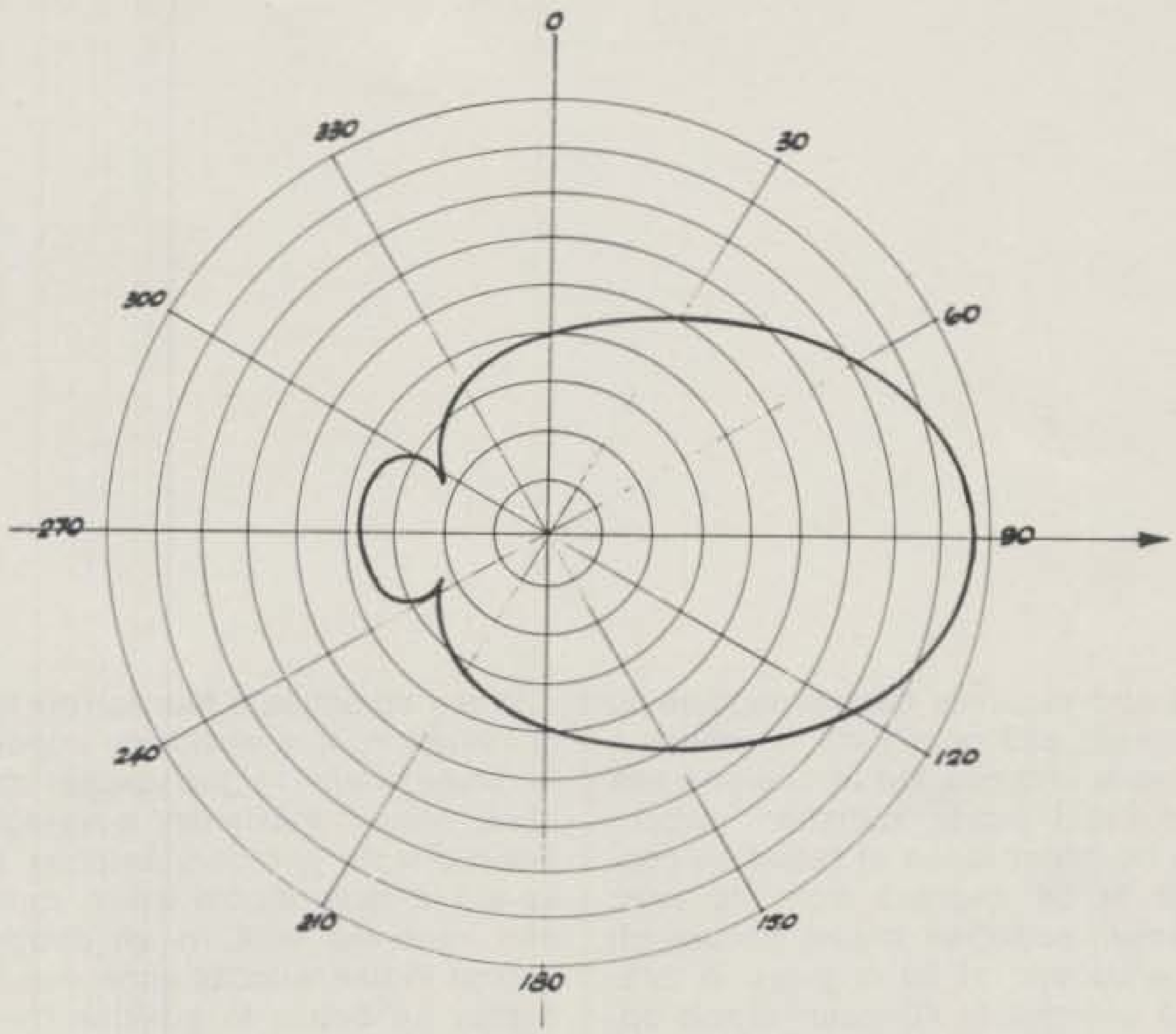


Fig. 7—The Polar pattern of the VK2SK X-beam, as plotted by ZL2NH.

lowest value of s.w.r. at the design frequency. He recommends that the tails be made longer than necessary and taped to the nylon line and folded back upon themselves. They can then be quickly pruned with cutters. Both elements are closely coupled and tuning one interacts with the other. As a result, the director is opened at the center and the driven element is then resonated to frequency. Once that is done, the director is adjusted for best performance".

"What kind of a pattern does the X-Beam have?", inquired Pendergast. He continued to draw in his notebook.

"A plot of the beam was run by ZL2NH, as shown in fig. 7. This is typical of a two or three element array. Obviously, the antenna works. And the results are very good for an assembly that only weighs about 4.5 pounds.

"Incidentally, you'll notice that the length of both elements is slightly longer than similar elements in a conventional Yagi beam. Extra-length elements are commonly required when the elements are folded back upon themselves, as is done in this design."

"Amazing", admitted Pendergast. "A 20 meter beam of this size and weight is certainly an eye-opener".

"An alternative design would be to eliminate the wire tails and extend the X-arms to their full length. You would have to adjust the lengths to compensate for the design change.", I said.

"How good is the bandwidth of the X-array?", demanded Pendergast.

"According to the article in *amateur radio,* the bandwidth is better than 2-to-1 across the 20 meter band. That's quite good for an array of this size and configuration".

Pendergast sighed and glanced at his digital wristwatch which gave the time, date, temperature and humidity. "Getting late", he said. "Nearly time

(Continued on page 89)

Fig. 8—CB antenna hardware provides inexpensive antenna mount for amateurs. The Turner type 800 mirror mount for CB whip doubles handily as a support for amateur whip. Device bolts to any horizontal pipe-like structure. An ideal arrangement for portable operation from a hotel or motel having a fire escape rail, porch railing or the like. Mount has a standard SO-239 receptacle.

bered detents are within the tuning azimuth of the conrol by placing the arrowed hole over all the detents. If a detent is not in the tuning range, place one of the holes of the manual present tuning control over the detent nut, place the locking key over the nut, and loosen it. With the key on the nut, rotate the control until the detent is within the tuning azimuth, and tighten the nut.

Second: set the bandswitch and manual preset tuning controls for the desired frequency. Place the arrowed hole over the desired numbered detent by rotating the manual-preset tuning control. Loosen the numbered nut with the key and lift the cam arm.

Leaving the key in place, rotate the control back to the channel frequency, push in the fine-tuning control and adjust it. Adjust the antenna trimmer for maximum signal. Rock the fine-tuning control. Tighten the numbered nut to secure the detent, push down the cam arm, and remove the key. ■

Antennas *(from page 53)*

for my schedule with Iraq. Guess I had better leave".

"Before you go, you might be interested in this gadget which has just surfaced in the CB market", I said, handing my colleague a photograph (fig. 8). This is a stationary mount for a CB whip antenna made by *Turner division of Conrac.* You'll note that it bolts to any horizontal pipe-like structure. This is ideal for portable work when you want to clamp a whip onto a railing, fire escape rail or a metal fance. The mount has a standard SO-239 receptacle."

"Not bad", said my friend. "This proves that something good comes out of CB radio from time to time. I may take it along with me on my next DX-pedition. I understand that the *Thousand Islands* in the gulf of St. Lawrence in Canada have just been made into one thousand separate countries. I think I'll go up there. That will keep me busy working DX for the rest of my life".

I reached into my pocket and withdrew a dollar bill. "Here. Take this", I commanded. "This will pay for my QSL card, just in case I never work you".

73, Bill, W6SAI

KC4NI *(from page 27)*

finally — to our wives and families who tolerated the whole thing, from start to finish. I must conclude with a personal thank you to Rick, W2EPA, who lugged his transceiver over to my rather equipment-barren shack and gave W2FYS a contact with Navassa. Two, actually, a c.w. and a phone QSO. I even have tape recordings of the latter (from both ends, yet!), so I have reasonable proof of a legitimate KC4NI QSO. At that, these are undoutedly the two most expensive QSL's I have ever obtained —about $500 each! Still, it was worth it. Thanks also to K2FT and W2PAU for the photography work . . . nice job, fellas. Finally, thanks to the other five members of the KC4NI gang for providing me with an experience I will never forget! *Where do we go next?* ■

Novice *(from page 55)*

Island, Novice **WM6EL,** has crystals on 7105, 7115, 7125, and 7145 kHz on 40 meters and on 21120, 21135, 21165, and 21189 kHz., according to **Ev Taylor, W6DOR,** of Golden West Crystals, who supplied the crystals. **WM6EL's** address is: **Wm. G. Pekelder, USN Station, Box 38, FPO, San Francisco, CA. 96614.** Another note from Ev to say that **Marilyn Kibler, WM6EC,** the wife of KM6BI, 7200 kHz, s.s.b., is also active on the Novice bands. Ev "got a kick out of" our suggestion to use the dishwasher to clean radio gear. He has been doing it for years. He advises, though, "Do not use it for a plastic chassis typewriter. What a mess!"

In the April, 1976, issue of *The Condenser,* the paper of the LaPorte, Ind., Amateur Radio Club, **Duane Mantick, WN9OMC,** compliments the graduates of the club's latest amateur study course. He then condemns the FCC for even thinking about a no-code v.h.f. license and doubts that there was such a thing as a law-abiding CB operator. But he has a simple, unworkable scheme to prevent these lawless characters from getting into the amateur bands: when they appear at the club's amateur course, refuse to give them the test! We doubt that the depraved characters he is talking about are going to bother to study for any license. But anyone, CB operator or not, who joins a course to study for an amateur license is the person we are looking for . . . **Susan Langley, WN4AKB/5,** 5712 N.W. 112 Street, Oklahoma City, Okla. 73132, earned her Novice license a year ago, when she was 13. Her Dad, **Dave, W4YDY,** appeared in our Novice column, as WN4YDY in the July, 1953, issue of *CQ.* She uses his Collins KWM-2 transceiver in conjunction with a Hy-Gain vertical antenna. Unfortunately, she neglected to mention what bands she works and whom. However, she is in the eighth grade; when she discovered that she could write on any subject for her term paper, she chose "Amateur Radio," which her instructor highly approved of. So do we.

At the bottom of the page already! Remember. This is your column. You are invited to write about your problems, as well as your triumphs in Amateur Radio. You will discover you are not alone. Send your "News And Views," suggestions of subjects we should discuss, and sharp pictures of yourself and station. Address your letters to: Herbert S. Brier, Novice Editor, CQ Magazine, 409 South 14th St. Chesterton, Indiana 46304. 73, Herb, W9EGQ.

WILLIAM I. ORR, W6SAI, ON

Antennas

"How's DX?", I asked.

"Pretty good," admitted Pendergast. He dropped the pen with a sigh and swept a pile of unanswered QSL cards to the side of his operating table. "Considering this is the bottom of the sunspot cycle DX has been amazingly good. I remember the bottom of the last cycle in summer of 1964. DX was *terrible* then. Why is it so much better now?"

"I don't know," I replied. "Better equipment. Better antennas. Better operators. A combination of all three?"

"Better antennas," Pendegast said confidently. "There are some pretty clever designs floating around, like 10 elements on a 160 foot tower . . ."

"Believe it or not, the greatest interest is in the simpler antennas. The majority of fellows can't put up the 160 foot tower, or anything close to it. Most of my mail consists of information about — and requests for — simple antennas. Small ones for apartment dwellers and fellows hassled by neigrbors, building inspectors and various restrictions."

"What about that loop antenna you have up on the garage?", demanded my friend.

*48 Campbell Lane, Menlo Park, CA 94025.

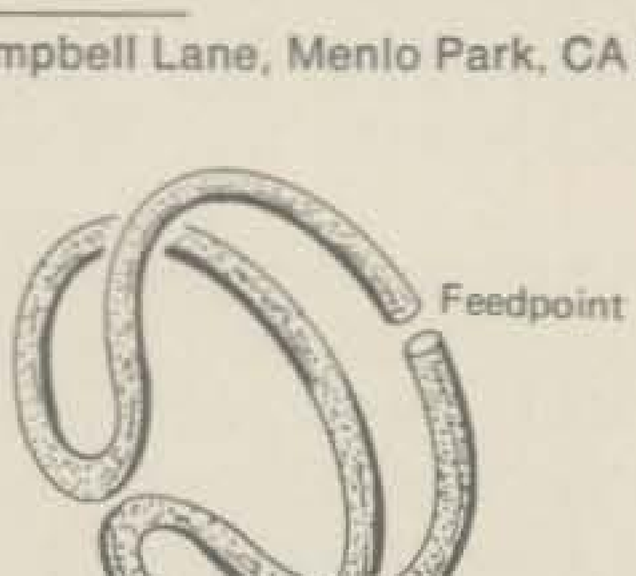
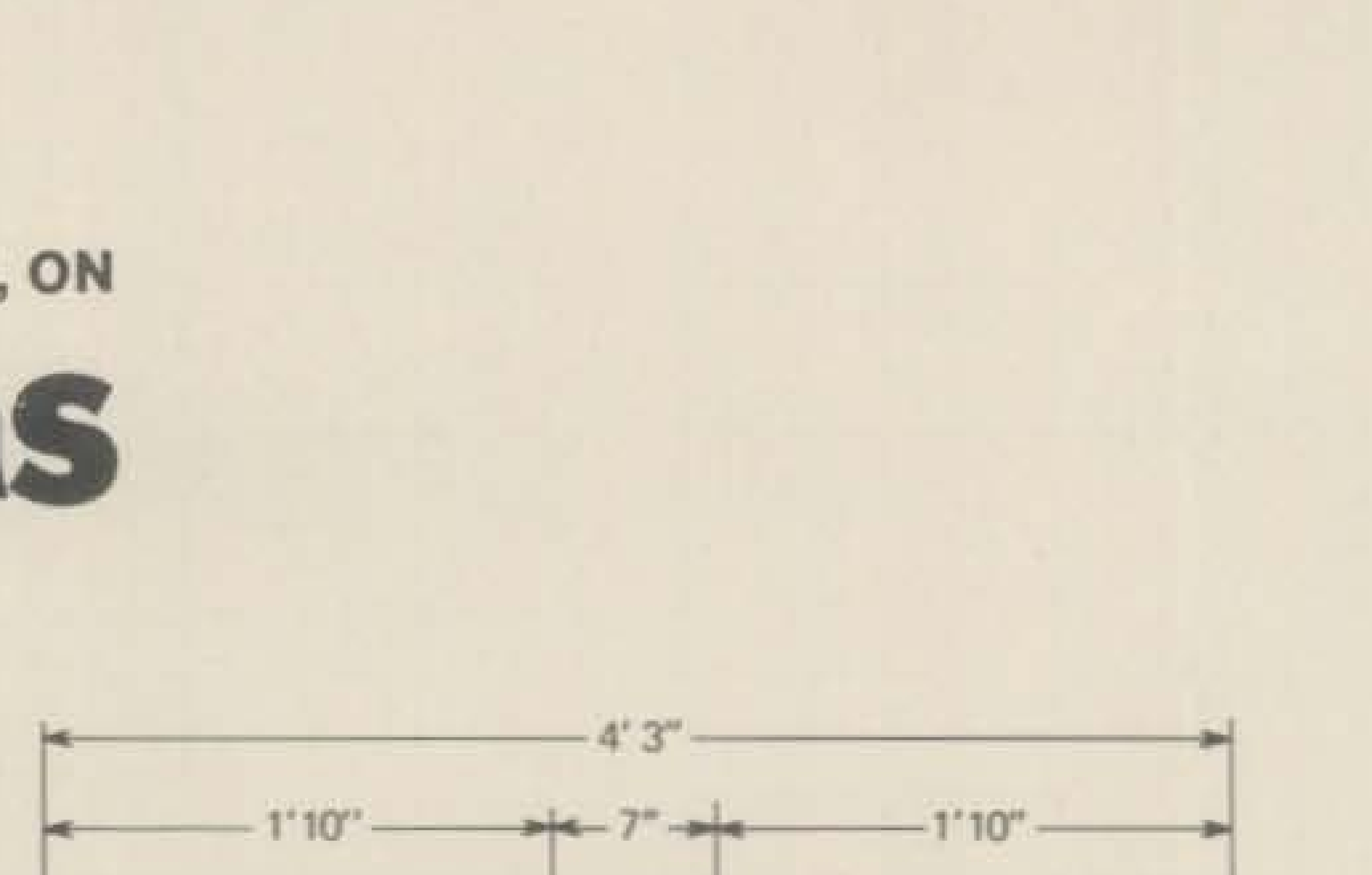


Fig. 1—The folded circular loop, or Halo antenna. When the folded dipole is bent into a Halo antenna the input impedance drops from 288 ohms to 86.5 ohms. The antenna exhibits positive reactance because of the capacity between antenna tips. By changing the diameters of the conductors, the input impedance can be adjusted to match a coaxial line. A single conductor Halo has an input impedance of 15.7 +j75.3 ohms.

Fig. 2—Layout of Halo antenna for 10 meters. Antenna is 4'3" square. Each wire length is 8'1". A seven inch separation is used at the high voltage point (top). Antenna is fed with a matching coil and one-to-one balun at the bottom (feedpoint). Radiation pattern is into and out of the page in a figure-8 configuration. Wood framework is shown in dotted lines.

Length of wire
on a side = 2' 0"
4' 3"
1' 10"
7' 13" or
8' 1"



"A good case in point", I replied. This design is based upon an article on folded dipoles and loops that appeared in the March, 1961 issue of *IRE Transactions on Antennas and Propagation*. The article was a comprehensive, theoretical study of antenna types done by C.W. Harrison, Jr. and R.W. King of the Sandia Corporation and Harvard University, respectively. A portion of the article concerned itself with the "halo" antenna (figure 1).

"The folded dipole style of halo has been used with some success as a mobile antenna for 6 and 2 meters and also is used for f.m. broadcasting. The dimensions of the dipoles can be adjusted to provide a good match to a 50 or 70 ohm line. Its a tough job to construct, however, especially for the lower frequencies.

"The single conductor halo, on the other hand, is very easy to construct, and that's the one I am testing at the present time. The input impedance of

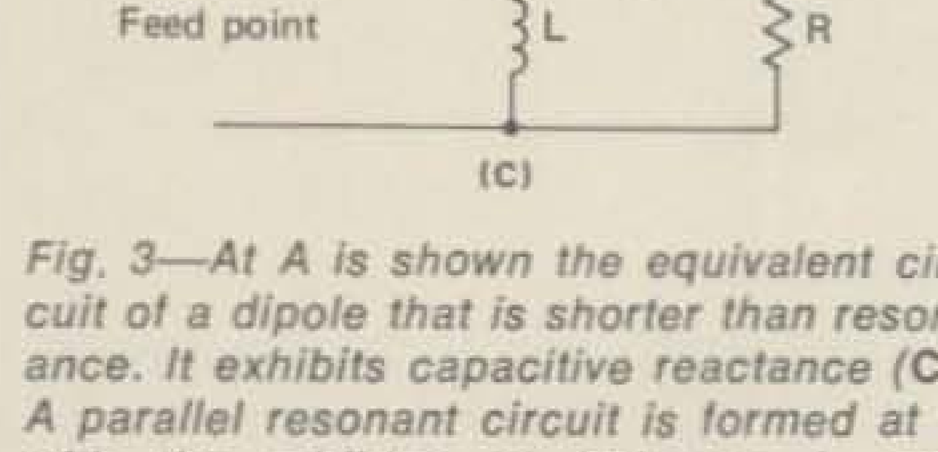


Fig. 3—At A is shown the equivalent circuit of a dipole that is shorter than resonance. It exhibits capacitive reactance (C). A parallel resonant circuit is formed at B with the addition of inductor, L. The equivalent L-network is shown at C.

this design, however, is quite low. According to the article, it runs about 16 ohms. In addition, the halo antenna should be cut a bit shorter than an equivalent dipole running in a straight line."

"What's your design?", asked Pendergast, as he pulled his ever-present notebook out of his attache case and prepared to make notes.

"Well, the design is shown in figure 2. Basically, it is a half-wave dipole bent into a square and mounted in a vertical position. It has the same radiation pattern as a regular dipole. My antenna is for 10 meters, but there's no reason why one couldn't be built for any h.f. band. Look! The 10 meter version is only a little over four feet on a side! That's small enough to be turned by the flimsiest of TV rotators."

"Let's talk about the electrical characteristics first", requested my friend.

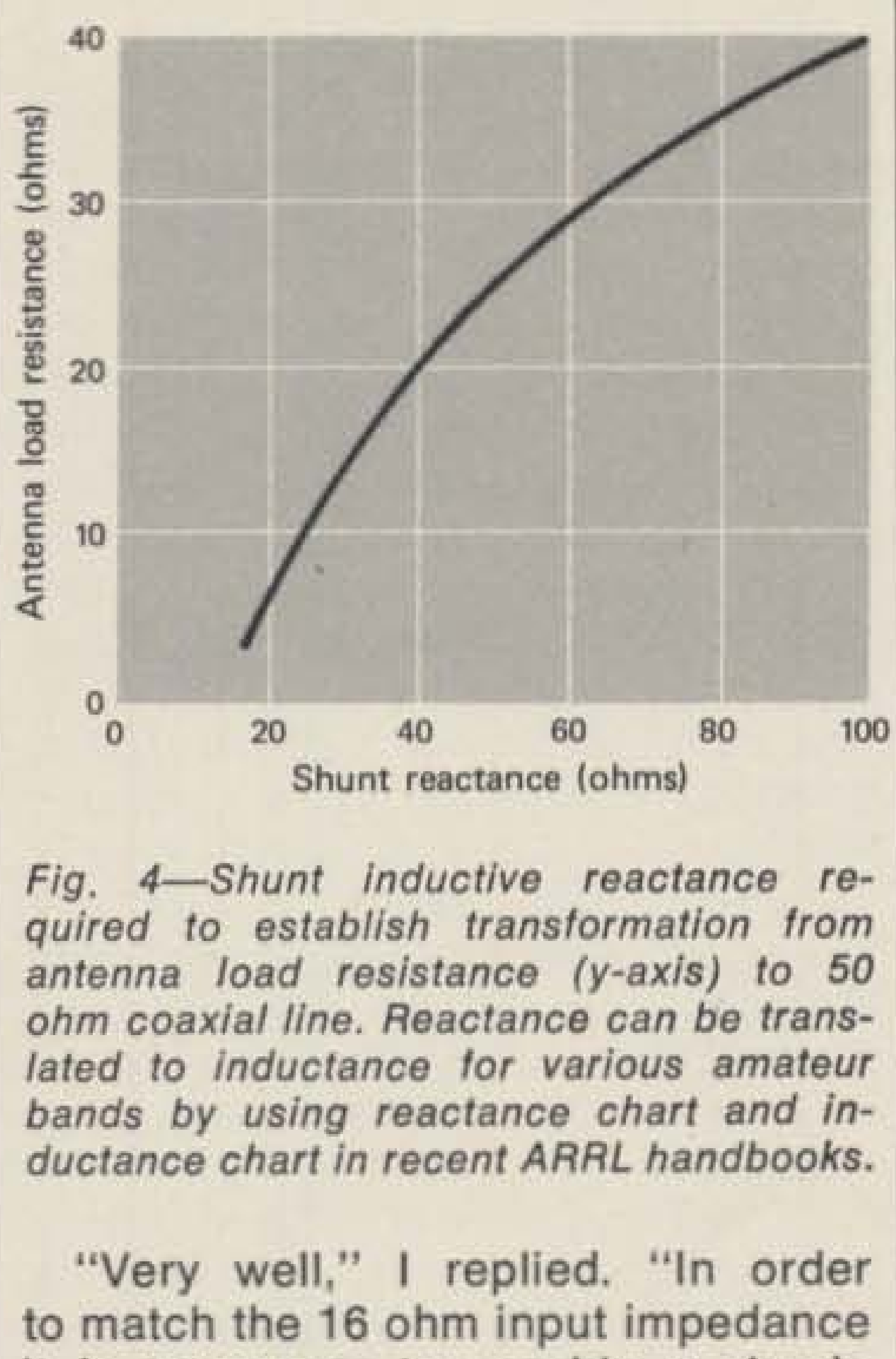


Fig. 4—Shunt inductive reactance required to establish transformation from antenna load resistance (y-axis) to 50 ohm coaxial line. Reactance can be translated to inductance for various amateur bands by using reactance chart and inductance chart in recent ARRL handbooks.

"Very well," I replied. "In order to match the 16 ohm input impedance it is necessary to provide a simple matching network for a 50 ohm coaxial line. This can be done by forming an equivalent parallel resonant circuit made up of the input impedance of the antenna and a shunt coil. If the antenna is slightly shorter than resonance, it looks like a series circuit at the terminals so all that is required is the coil placed across the antenna terminals, as shown in fig. 3

"Without going into the mathematics of it, the data in figure 4 translates everything into practical terms if you know the input impedance, or radiation resistance, of the antenna. For this little mini-loop, it is 16 ohms. To match it to a 50 ohm line, the inductor required has a reactance of about 35 ohms."

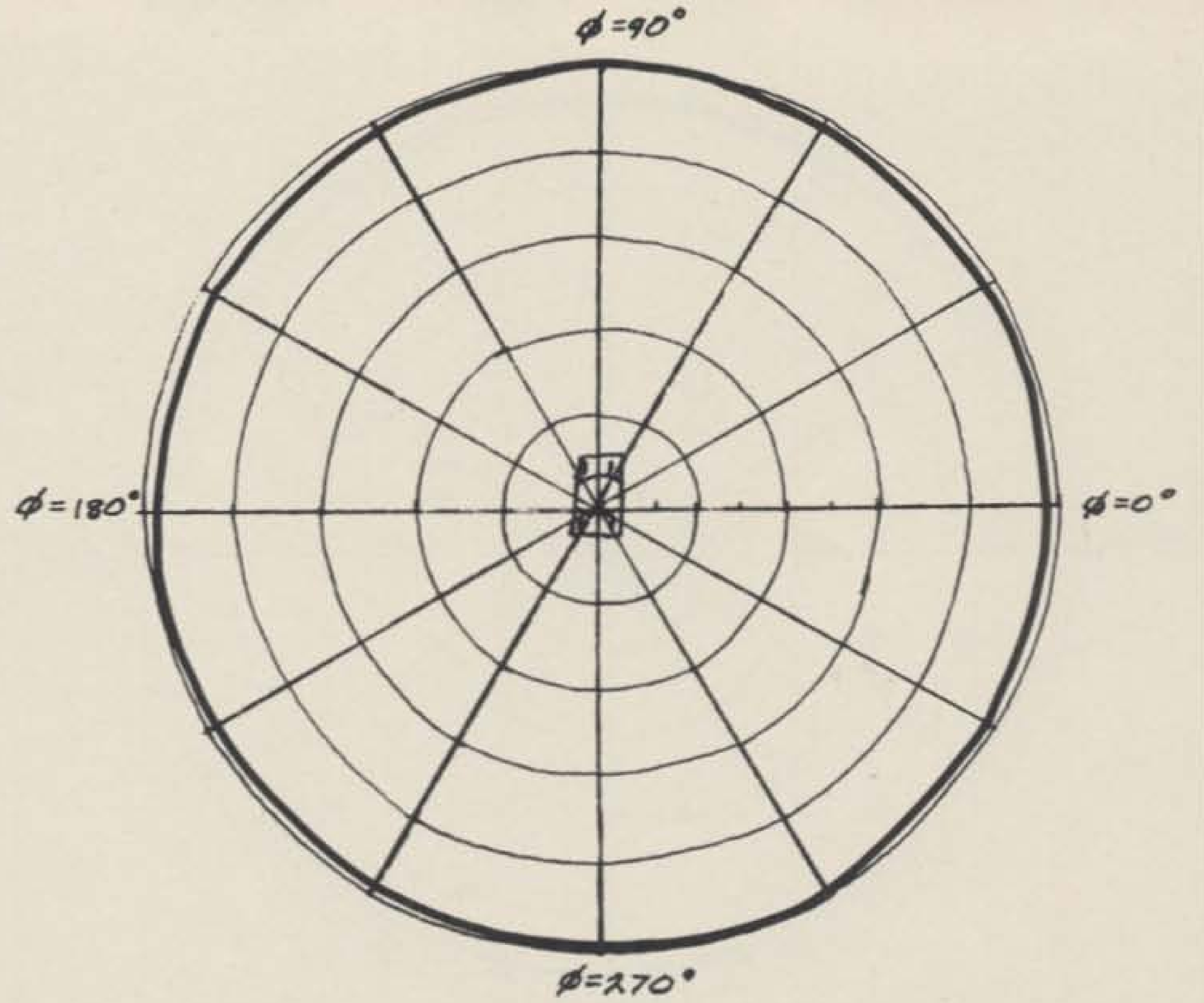


Fig. 5—Typical free-space horizontal plane pattern of vertical antenna mounted in center of roof of automobile. Drawings courtesy Communication News, *a Harcourt Brace Jovanovich publication.*

"How do I get from inductive reactance to the nitty-gritty of how-many-turns?", asked Pendergast.

"The easiest way is via a reactance chart, such as on page 44 of the 1976 edition of the *ARRL Handbook*. According to the chart, a reactance of 35 ohms on the 28 MHz band is equivalent to an inductance of about 0.2 microhenries. You can now trans-

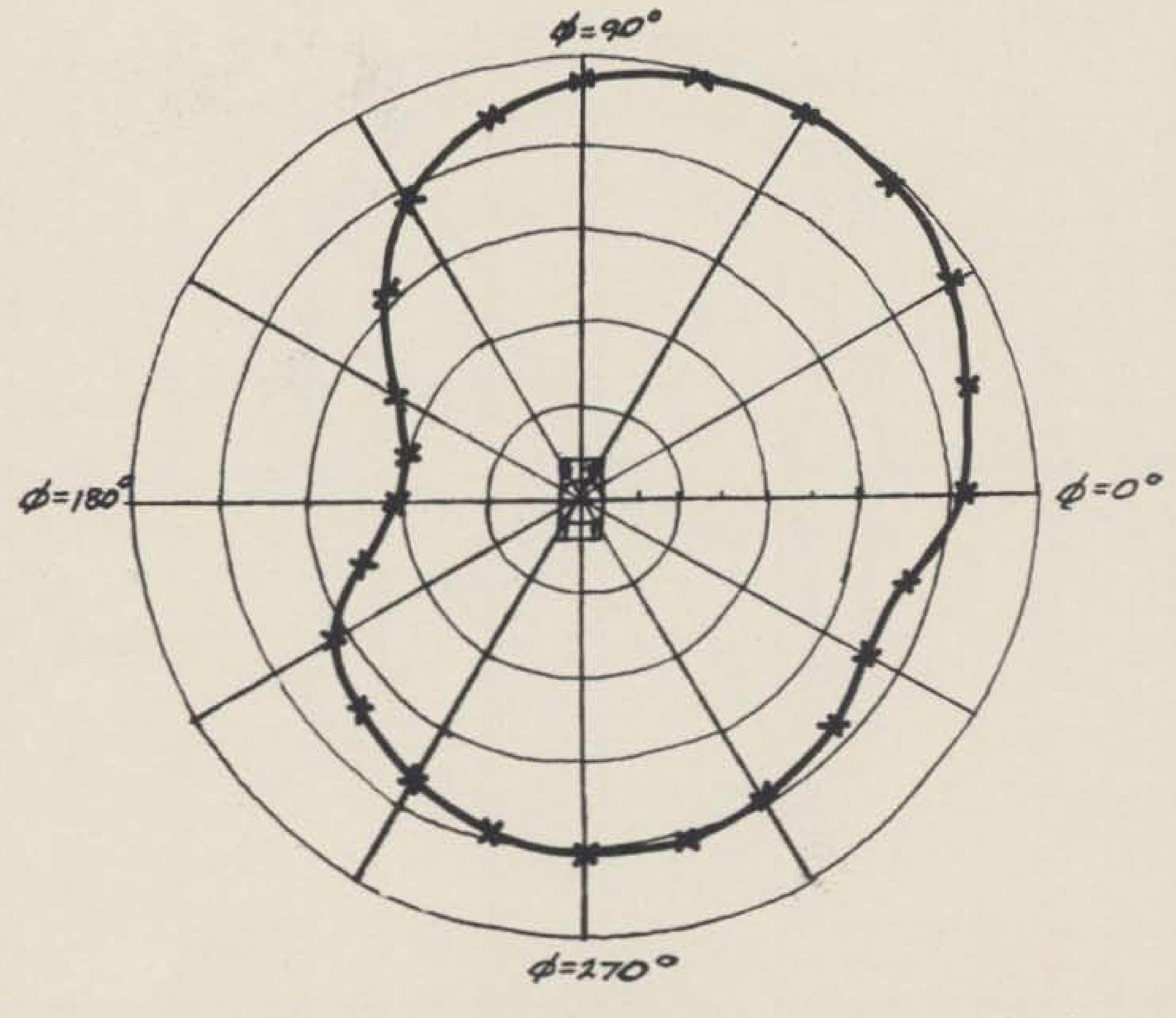


Fig. 6—Field intensity plot for whip antenna mounted on left, rear vehicle bumper. Field strength is down about 6 dB to left of vehicle.

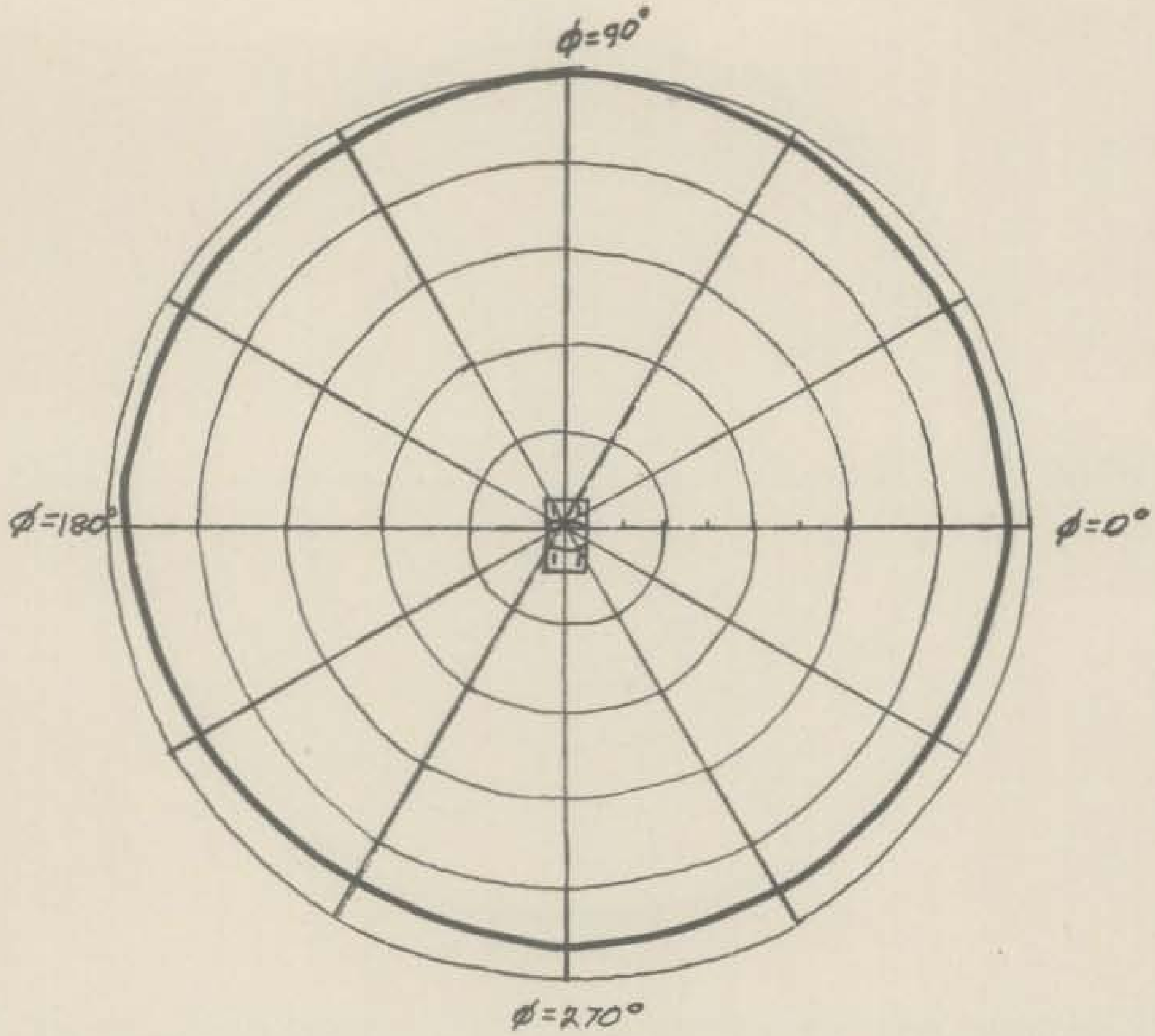


Fig. 7—Field intensity plot for whip antenna mounted on trunk of vehicle. Pattern is nearly omnidirectional.

late this into a real-life coil by turning to the inductance chart on page 27 of the same handbook. An inductance of 0.2 microhenries is equivalent to about 5 turns of #12 bare or enamel-coated wire, ½ inch inside diameter and wound at 8 turns per inch. The coil is therefore ⅝ inch long."

"Why don't they place the two graphs on one page?", grumbled my friend.

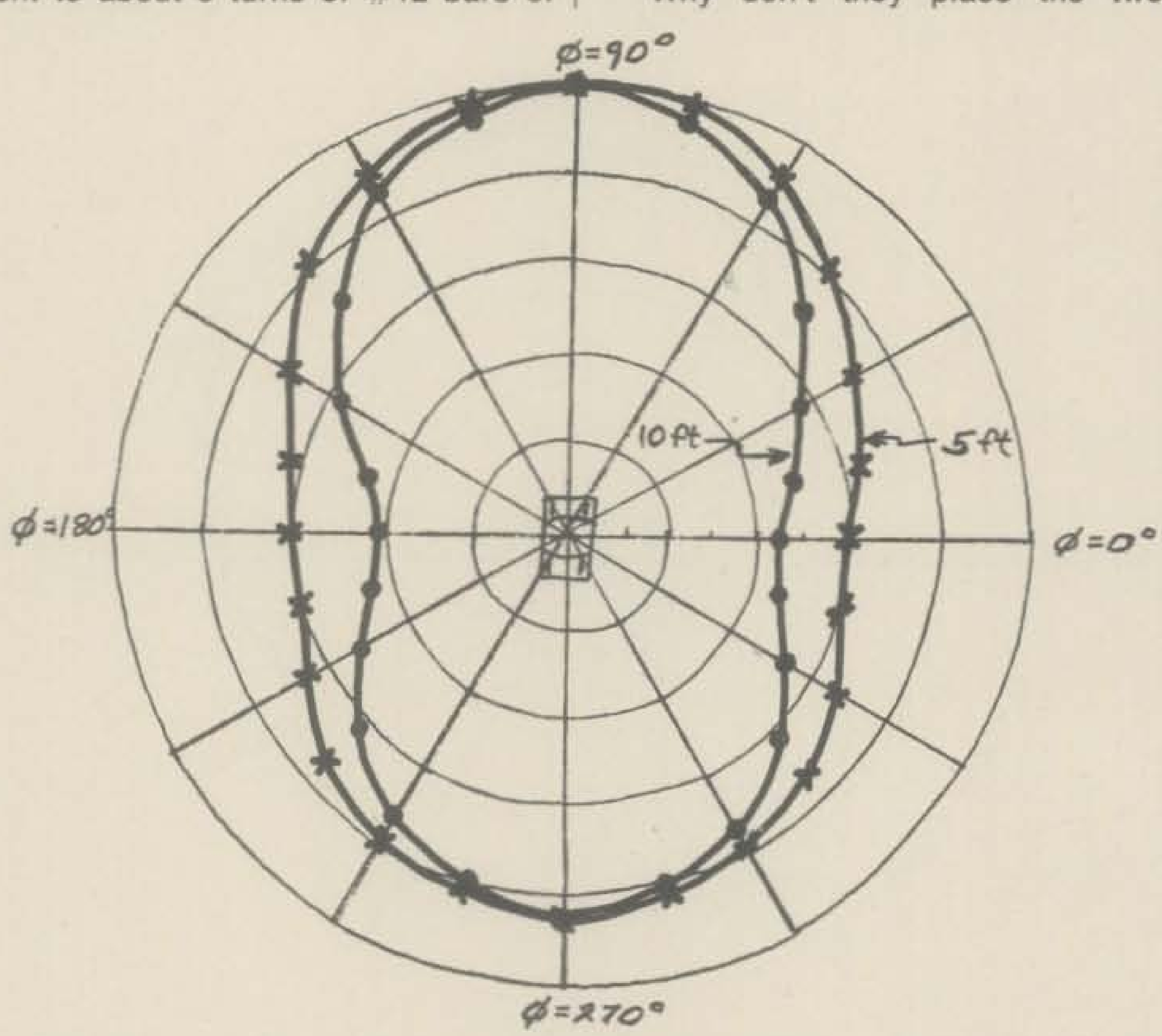


Fig. 8—Co-phased whip patterns with 5 and 10 foot separation show deep nulls to the sides of the vehicle. Ten foot separation provides 6 dB nulls, whereas 5 foot separation shows 4 dB nulls.

"Well, they want you to think a *little*", I replied. "Now, once you have figured out the coil and mounted it across the antenna terminals, the last step is to place a 1-to-1 balun transformer between the feedline and the antenna terminals. The coil, antenna and balun connections all are in parallel at the feed point.

"The s.w.r. curve of the mini-loop is quite sharp, providing a bandwidth of about 250 kHz. By adjusting the coil and the length of the wire in the loop, however, it is easy to zero-in at your pet operating frequency. My loop is adjusted to 28.6 MHz and works great from 28.5 MHz to 28.7 MHz. And the s.w.r. is less than 2-to-1 across that range".

"Now, how does it all go together?", demanded Pendergast. "You must remember that all the tools I have are a hammer and a dull Boy Scout knife!"

"No problem at all", I laughed. "My mini-loop was made of materials from the local hardware store. I used a square piece of plywood for the center plate. The wood pole and the arms are made out of 1-inch diameter hard dowel rod. The poles are clamped to the plywood plate with small U-bolts. Holes are drilled in the tip ends of the dowels for the antenna wire. The #16 antenna wire is strung through the holes and fastened to the top insulator. This must be a good insulator with a long leakage path, as it is at a point of high potential. I used two, 3-inch ceramic insulators in series. Once the loop is assembled, the center U-bolts are loosened a bit and the dowel rods pushed out to tighten the wire. And I gave the wooden framework a coat of boat varnish to make everything waterproof.

"The wood pole is jammed into a support pipe. You don't want the pipe to come up into the electrical field of the antenna, so there's a section of pole that extends under the loop for nearly two feet. The support pipe is a TV slip-up mast, shimmed at the top to make a tight fit with the wood pole. I use a TV rotator to turn the little loop".

"How does it work?", asked Pendergast as he continued to make graceful drawings in his notebook.

"Damn good", I replied. "It doesn't have the sock of my beam, but I've worked plenty of short, summer skip on 10 and have gotten excellent reports. It seems to be down about 6 db on direct comparison tests with the beam, which is about right, I guess".

"Looks like a nice job for portable operation", observed my friend. "In fact, if it was just a little bigger, it would make a good CB antenna".

"Perish the thought," I replied.

"Speaking of CB antennas", said Pendergast, as he pulled a large magazine out of his jacket pocket, "Did you see the article on co-phased mobile whip antennas in the June, 1967 issue of *Communications News?* It is written by Dave Rayburn of Breaker Corporation and he discusses the operation of twin whips on an automobile or truck. Lotsa CBers use twin whips, but I've never seen a mobile amateur installation with twin whips. Is it a good idea, and why not use it on 10 meters?"

"Slow down", I said. "I remember some of the early 80 meter mobile operators used twin whips, connected in parallel, in order to reduce corona effects when running high power a.m. That was a long time ago. But the CB twin whips are different in that they are co-phased in the broadside condition. Theoretically, this is a simple bidirectional beam antenna. Look at figure 5. That's a field intensity plot of a single vertical whip antenna mounted on the center of a vehicle roof. A nice, omnidirectional pattern. But look at figure 6. Now the whip is mounted on the left, rear bumper of an automobile. The field pattern is all screwed up, with most of the radiation over the right, front fender direction and very little to the left of the vehicle.

"Now, when the whip is mounted on the trunk of the vehicle, the pattern is more omnidirectional, as shown in figure 7. This is not bad.

"But the problem arises as to antenna placement on the big semi-rigs, or "sixteen wheelers", as the CBers call them. About the only clear location for an antenna — away from the body of the vehicle — is on a side mirror mount. And that gives a skewed pattern similar to that of the bumper mount.

"The final solution is to use two whip antennas, co-phased, mounted on each mirror mount. Co-phasing is simple — just use equal lengths of coaxial line and connect the lines in parallel at the transmitter. When that is done, the antenna field pattern resembles that shown in figure 8. With 5 foot separation, the pattern is figure-8 shaped, in-line with the body of the vehicle. Radiation off to the sides is down about 4 decibels compared to the field strength in-line with the vehicle. Five foot separation is about that found on most automobiles".

(Continued on page 73)

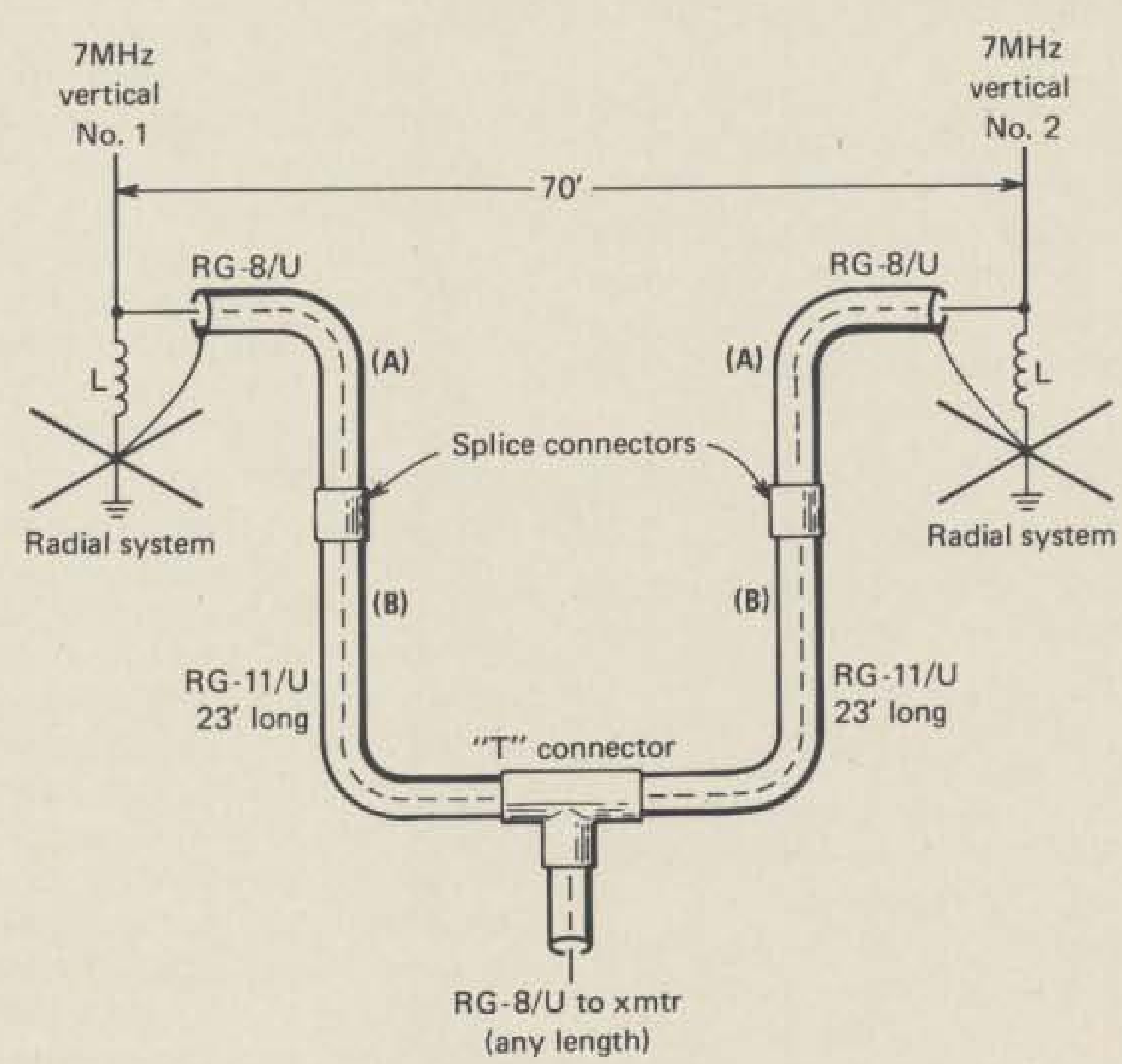


Fig. 9—Co-phased vertical antennas for 40 meter band. Each antenna employs matching inductor (see figs. 3 and 4) to bring base impedance up to 50 ohms. Forty meter vertical exhibits typical base impedance of about 40 ohms, so shunt reactance (L) of 100 ohms is required. This works out to 2.3 microhenries at 7 MHz. This would equal 12 turns #14 wire on a 1-inch diameter form, wound 10 turns per inch. Length of line sections (A) is unimportant, so long as the lengths are equal. Line sections (B) are each 23 feet long to tip of plugs. Length of antennas and base inductors are adjusted to provide low s.w.r. on 50 ohm line to station.

Bibliography

1. MM5736 Data Sheet
2. AN 112
3. AN 119 all National Semiconductor

QRP *(from page 45)*

News

Things ought to be picking up for QRPp DXers on the high bands, and for the guys who like 40 and 80. We haven't had any applications for QRPp DXCC for several months now. How are things going? I'd like to devote the bulk of some future columns to reports from our readers. So, if you've been active and would like to share some of your experiences and savvy with our readers, take pen in hand. Also, I'd really appreciate (and so would our readers!) pictures of fellow QRPp'rs, so let's get on the ball! Remember that the big *CQ* WW DX bash this fall will have a special, separate QRPp section if current plans work out. So get planning on that effort right now. Let's have a good showing. It is high time some "biggie" organization like *CQ* (or *QST?* naw, never) recognized that QRPp operators have been participating in these contests that everyone assumes are reserved for the QRO guys. At least thirty entries first time out! Until next month, then.

73, Ade, K8EEG

Antennas *(from page 41)*

"Well", interrupted Pendergast, "It seems to me that the fellows using twin whips on automobiles don't gain a thing. In fact, they loose signal strength to the sides of the automobile".

"That's right", I agreed. "And look at the situation with 10 feet spacing. No improvement in gain, and the signal strength is down about 6 dB off the sides of the vehicle. Even so, most operation of the big trucks — speaking from a communication point of view — is up and down the highway, so the figure-8 pattern is probably a good thing. It helps to reduce interference a bit from stations to the sides of the road. And it improves the poor pattern of a single whip mounted on a big semi-rig. But all the use of twin whips on an automobile does is to inflate the ego of the user, as far as I can tell."

Pendergast sighed heavily. "I guess I'll stick to 2 meter f.m. and my nineteen-inch whip antenna".

"Don't sell the vertical antenna short", I answered. "I received a very interesting note from Dave, W0FCL, in Great Bend, Kansas. Dave has been working with 40 meter vertical antennas and has evolved a very simple and effective version of the well-known phased vertical array (Figure 9). The verticals are spaced a half-wavelength apart and are fed in phase to produce a broadside pattern (into and out of the page). He uses a TV mast for one vertical and an aluminum tubing mast for the second vertical. They are guyed with nylon rope and sit on soft drink bottles. He recommends plenty of radial wires.

"The feed system is quite simple. Each antenna is matched at the base with an inductor (as is done with my mini-Quad loop) to provide a feed point impedance of 50 ohms. Then, each antenna has an equal-length section of 50 ohm line (A), followed by a quarter-wavelength section of 70 ohm line (B). This works out to 23 feet for either RG-59/U or RG-11/U. The 70 ohm transformer steps the impedance of each antenna up to about 98 ohms. A coaxial T-connector is used to connect the antennas in parallel, dividing the circuit impedance by two to about 49 ohms. From this point, a 50 ohm line is run to the station equipment.

"It is easy to tune up the system. Adjust each antenna by itself to provide a base impedance of 50 ohms. This is done with the aid of a dipmeter and Antennascope. A noise bridge may be used, if desired. Antenna length and matching coil turns are adjusted together. As a final check a 50 ohm line may be run separately to each antenna and the antenna adjusted for minimum s.w.r. on the line. Once this is accomplished, the antennas are parallel connected through the 70 ohm transformers and T-connector.

It should be possible to reach 1.2-to-1 s.w.r. when the antennas are working together. In this case, the antennas are resonated at 7.06 MHz for full band coverage".

Pendergast asked, "How do they compare against a simple dipole?"

"Dave says the two antennas outperform his inverted-V dipole at distances over 600 miles. He has placed the whips to give east-west coverage".

"Well, I *know* the antenna works", responded my friend. "I've heard W0FCL and he suffers no pain in working DX".

"That's right," I replied. "It's hard to be loud on 40 meters, and I take my hat off to the fellow who has the energy, time and space to put up a good antenna system. I think I'll just go home and sulk about it for a while, since all I have is a wire running out to a tree in the rear of the yard!" ■

WILLIAM I. ORR, W6SAI, ON

Antennas

A swirl of leaves swept against the window of the radio room and the antenna atop the tower trembled gently in the increasing blasts of the wind. It was still afternoon, but the days were getting shorter and the nights colder.

"Winter will soon be here", said Pendergast, interrupting my thoughts. "Better get all your guy wires in shape and the antennas tied down for the wintry weather. Everyone says snow will come early this year". He shivered elaborately and settled down in his operating chair.

"That reminds me," I replied. "Here's an interesting little chart that I found in the January, 1934 issue of *I.R.E.* That was the month I got my ham license, so I was looking through the back issues to see what was going on in the world of shortwave radio at that time. Look at this graph (fig. 1)".

Pendergast peered over my shoulder at the drawing. I continued,

*48 Campbell Lane, Menlo Park, CA 94025.

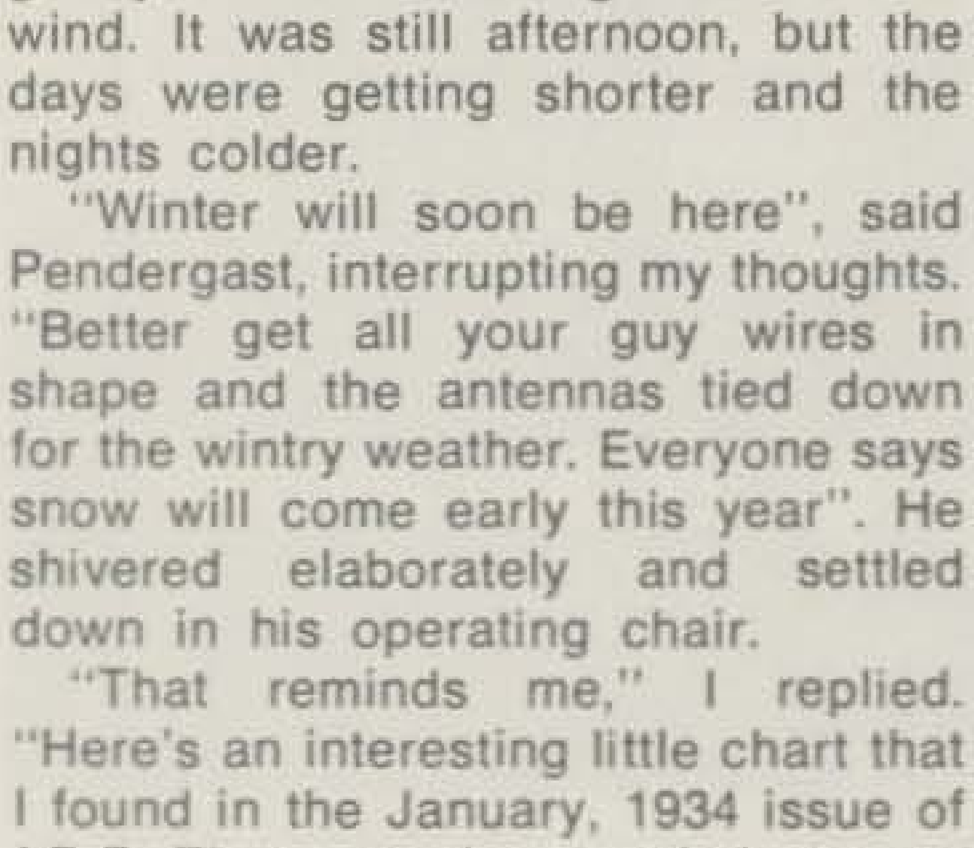


Fig. 1—Radiation resistance as a function of height for a dipole above ground of good conduction. "Classic" curve is for perfectly conducting ground. Real-life measurements show that radiation resistance exhibits much higer values than assumed for antenna heights less than 0.2 wavelength. Increase in radiation resistance is probably due to ground losses.

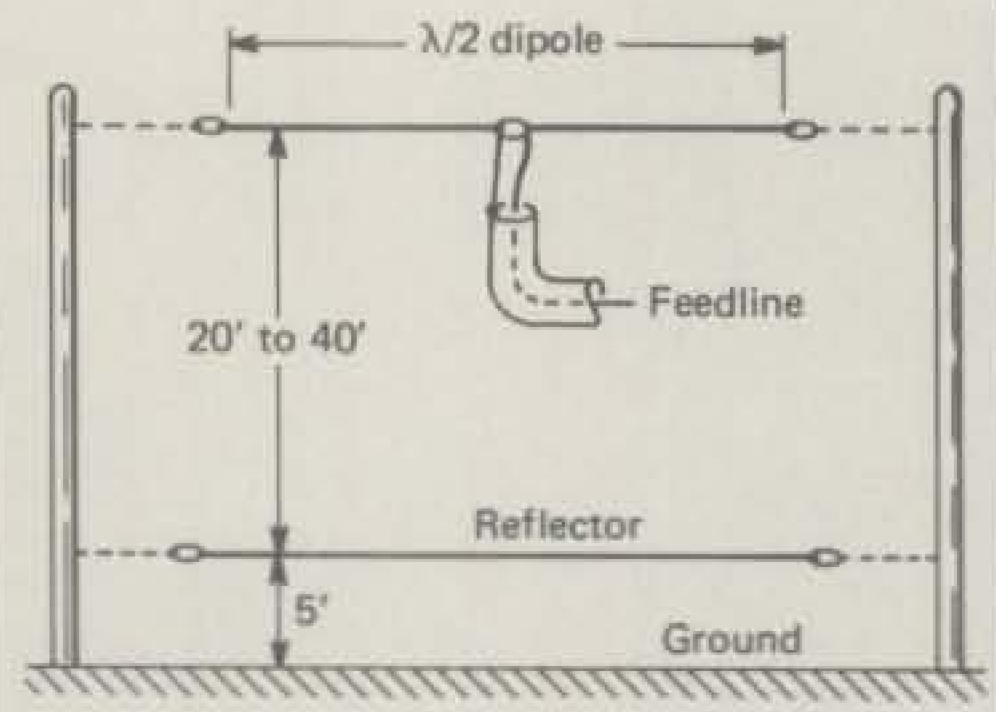


Fig. 2—Ground losses may be reduced by placing a reflector wire beneath the dipole. Length of the reflector is about 5 percent longer than that of dipole. Dimensions shown are for 80 meter band.

"This data was run by engineers of the *Bell Telephone Laboratories* on a dipole antenna suspended over a good, earth ground. Compare it with the curve for perfectly conducting ground, such as a copper screen! This explains why it is possible to feed a low, 80 or 160 meter dipole with a 50 ohm coaxial line and get a reasonably good impedance match and a low value of s.w.r. at antenna resonance.

"For example, an 80 meter dipole with an average height of 20 feet above the ground is about .08 wavelength high. According to theory the radiation resistance of such an antenna is only about 18 ohms. Thus, the best value of s.w.r. at resonance is 50/18, or about 2.8-to-1. Most of my 80 meter dipoles erected over the years have run much closer to 1.5-to-1, or even better than that. Now, according to this chart, a dipole placed at .08 wavelength above a good ground really exhibits a radiation resistance of about 54 ohms. And that would give an s.w.r. figure of only 1.1-to 1."

"Gee, that's great", enthused my friend. "Ho, ho, all the Handbooks are *wrong*, including yours!"

"Not so fast," I replied. "Although the article doesn't state it, I'll bet a lot of the so-called "radiation resistance" at the lower antenna elevations is really *loss resistance*. The earth is an imperfect conductor and, when in close proximity to the dipole, some of the radio energy is bound to be lost because of the resistance of the earth to r.f. currents. So this curve really tells us that at heights of less than about 0.2 wavelength, or heights of less than 50 feet or thereabouts, the ground losses associated with an 80 meter horizontal antenna rise rapidly. This corresponds to heights of 25 feet on 40 meters and 100 feet on 160 meters".

"Bah!", exclaimed Pendergast with a frown. "Are you telling me that a dipole won't work at heights of less than 0.2 wavelength?"

"Not at all", I replied. "This interesting graph merely tells you that ground loss exists when the horizontal antenna is in close proximity to the ground and that the radiation resistance—or input resistance, if you prefer, plus the ground loss resistance adds up to provide a total figure in the vicinity of 50 ohms. As a result, the low dipole provides a somewhat better s.w.r. figure at resonance than one is led to believe from studying the theoretical case".

"The graph tells you even more than that", I continued. "At an an-

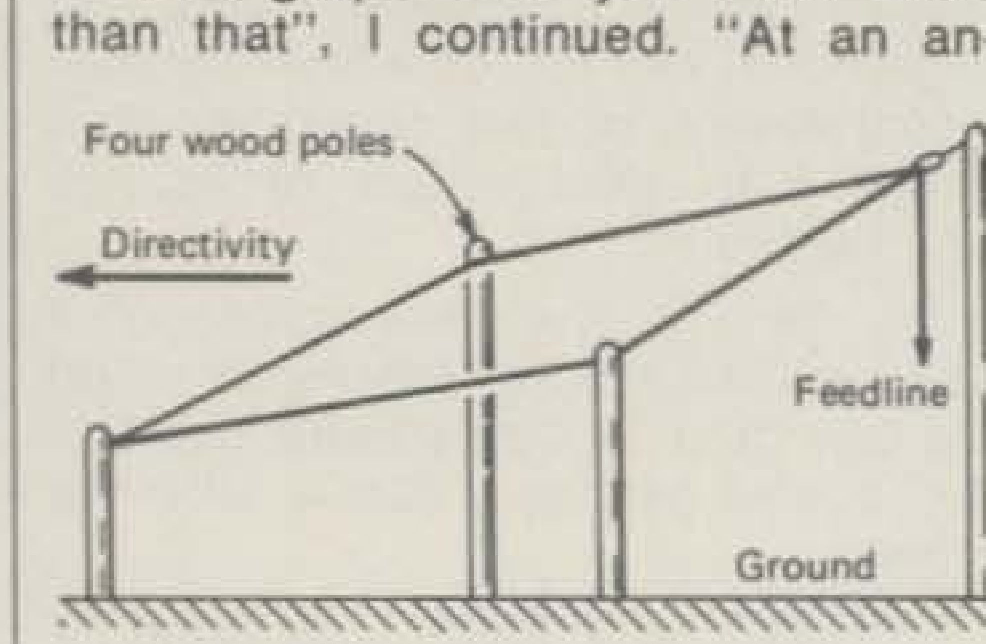


Fig. 3—The tilted Quad loop of WA4BAX. Dave uses this antenna on 80 meters. Tilting the loop picks up about 3 db in the favored direction and drops the signal about 3 db in the reverse direction. Length of wire in the loop is 1005/f (MHz). W4TYH uses an antenna like this about 50 feet high with a 5 percent larger square reflector beneath it to reduce ground loss.

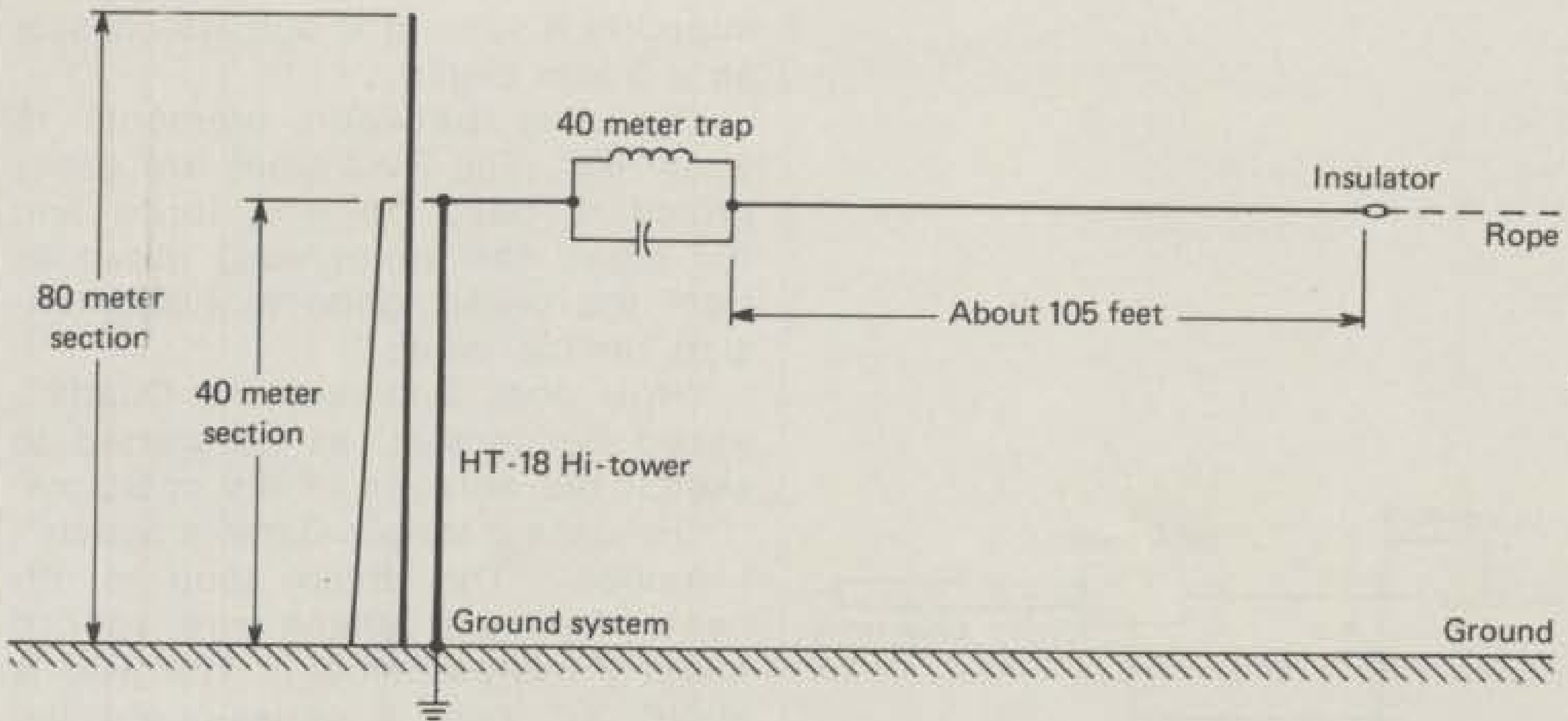


Fig. 4—The add-on 160 meter antenna of W2GHK/4. Hi-tower has 40 meter trap added at top of 40 meter section (tower) and single wire resonates system to 160 meters. Stu used a Hy-gain trap but a substitute can be made of a 100 pF, 5 kV ceramic capacitor (Centralab 850SL-100N). Coil can be 9 turns No. 12, 2½ inches diameter, 6 turns per inch (B&W 3029). Spread end turns to resonate trap on bench to 7.1 MHz before installing in antenna.

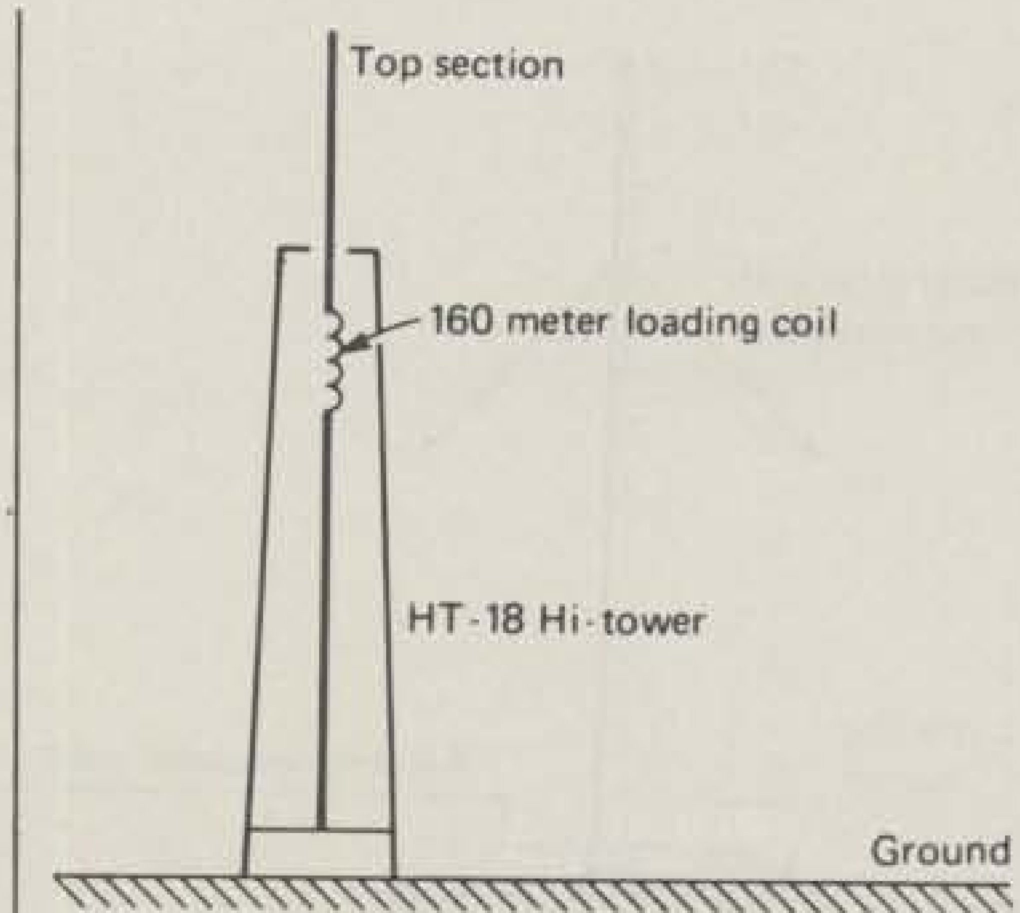


Fig. 5—W5UTV puts his Hi-Tower on 160 meters by adding a loading coil to the 40 meter section. He placed a surplus coil about 3½ inches in diameter in series with the 40 meter wire and adjusted the number of turns to provide resonance at 1805 kHz. Later, he extended the top section to make antenna 65 feet high. Eight radials, 130 feet long are used in addition to a ground screen and 8 ground rods. Al adds about 200 pounds of rock salt to the soil once a year to improve the ground. He says the rock salt is "guaranteed to kill the weeds even if it doesn't make you louder!"

tenna height of 0.1 wavelength, for example, the observed value of radiation resistance is about 45 ohms Theory says it is only 21 ohms. The difference, or 24 ohms, represents loss resistance. Antenna efficiency is thus 21/45 or 46 percent. Just about half your power is lost in warming the ground."

Pendergast sighed heavily. "Well, if you can't get your antenna up in the air at the lower frequencies, you'll just have to accept the ground losses. I wonder if a ground screen under the antenna would do any good?"

"From the data, I would imagine it would", I replied. "But it would have to be quite large. One stunt that some 80 meter operators have done is to place a *reflector* beneath their antenna (fig. 2). The idea is that the reflector beams the energy upwards, away from the lossy ground beneath the antenna. The idea might have some merit to it".

"Pretty sneaky", murmured my friend. "Anything else on the subject of low frequency antennas?"

"Yes", I replied. "I received a note from Dave, WA4BAX recounting his experience with an 80 meter "Lazy Quad". He slopes it in the direction he wishes to work (fig. 3). This antenna was popularized by Clarence Moore, W9LZX, the inventor of the Quad. It was described in *CQ* some time back. Dave tilts his antenna and picks up about 3 db in the desired direction, although he can work DX in any direction. He also says that W4TYH (Gene) uses an antenna like this at 50 feet, but with a 5 percent larger square reflector *beneath* it. He's worked into VK and ZL with it, so it sounds like a good DX antenna for 80 meters."

"How about vertical antennas for the low bands? Any ideas?", asked Pendergast, as he made a sketch of the Lazy Quad in his notebook.

"Yes", I replied. "I got a nice note from W2GHK, Stu. He's got a *Hy Gain* "Hi-Tower" and operates it on 160 meters (fig. 4). Basically, the Hy-Tower consists of a 40 meter, ¼-wave vertical in parallel with a ¼-wave, 75 meter vertical. The 40 meter section consists of three 8 foot sections of tower (24 feet) plus a short length of tubing attached to the tower top to achieve resonance. The 75 meter section consists of 27 feet of telescoping tubing coming out of the top of the tower to make a total height of 51 feet. The tubing is attached to a wire run down the inside of the tower to the feed point at the base. This assembly works well on the lower bands and decoupling stubs are attached to the tower for the higher bands, up to 10.

"The W2GHK modification consists of installing a 40 meter trap *(Hy-Gain)* at the top of the tower section, as shown in the drawing. This provides a mechanically stable attachment. The other end of the trap is connected to 105 feet of wire run parallel to the ground to form an inverted-L antenna for 160 meters. The wire can be trimmed to "zero-in" on your pet frequency. Stu says he had no trouble getting the s.w.r. down to near-unity with the s.w.r. reading rising to more than 1.5-to-1 over 100 kHz.

"When the trap is connected to the top of the tower, the s.w.r. does not change on any of the other bands. The only effect noticed was that the

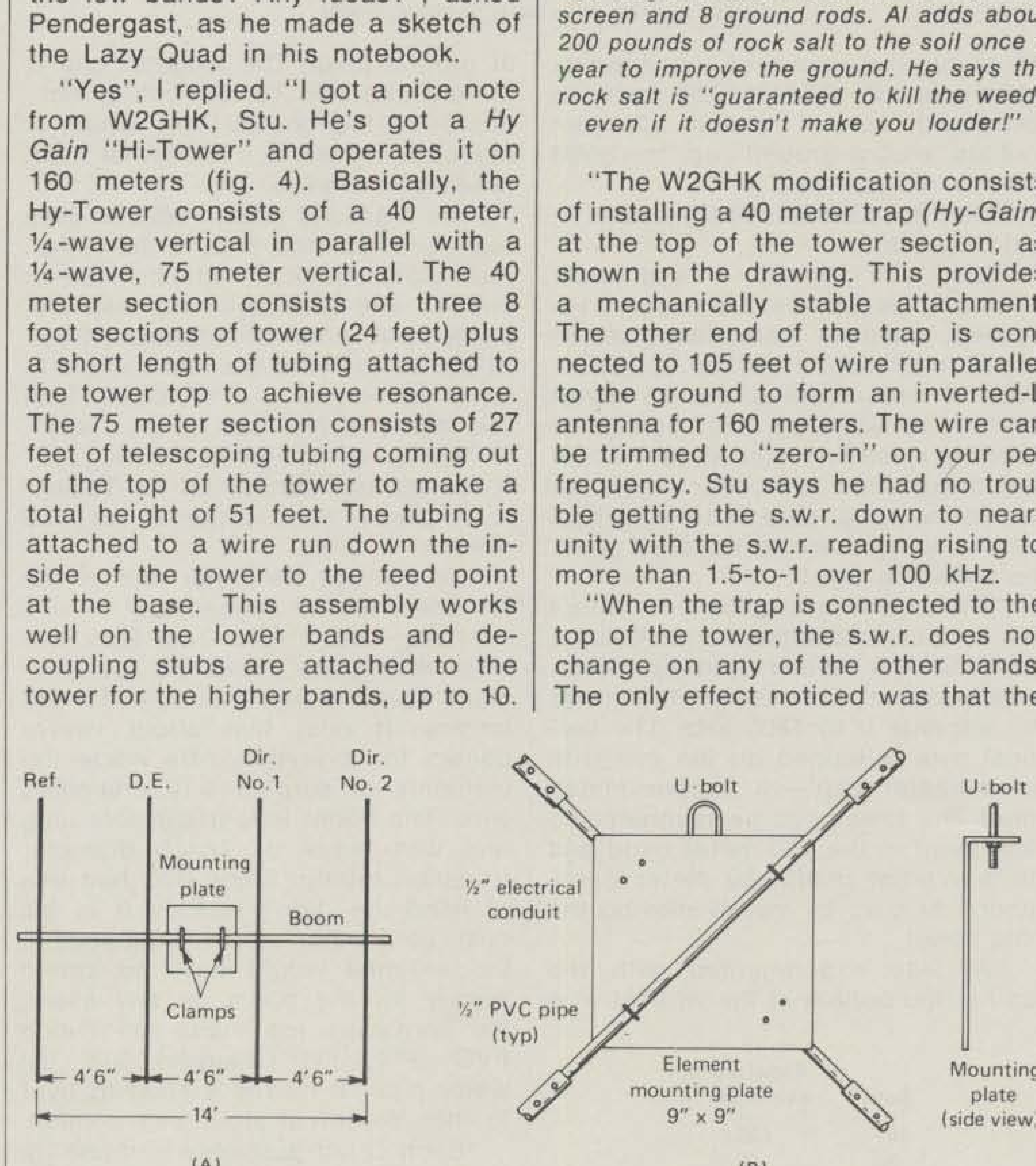


Fig. 6—Rugged Quad design is suggested by K4HTU. This 10 meter design uses a 14 foot boom. The element mounting plates are 9″ × 9″ squares of aluminum hung from the boom by galvanized U-bolts. A similar plate is used to bolt the boom to the support mast. Each element arm is made up of two 6-foot lengths of plastic PVC pipe pressed onto a three foot length of electrician's metal conduit. This makes an arm about 13′6″ long. The arms are cross-mounted on opposite sides of the element mounting plate by means of U-bolts. Overall layout of the Quad is shown at (A) and a typical mounting plate is shown at (B). A gamma match is used on the driven element.

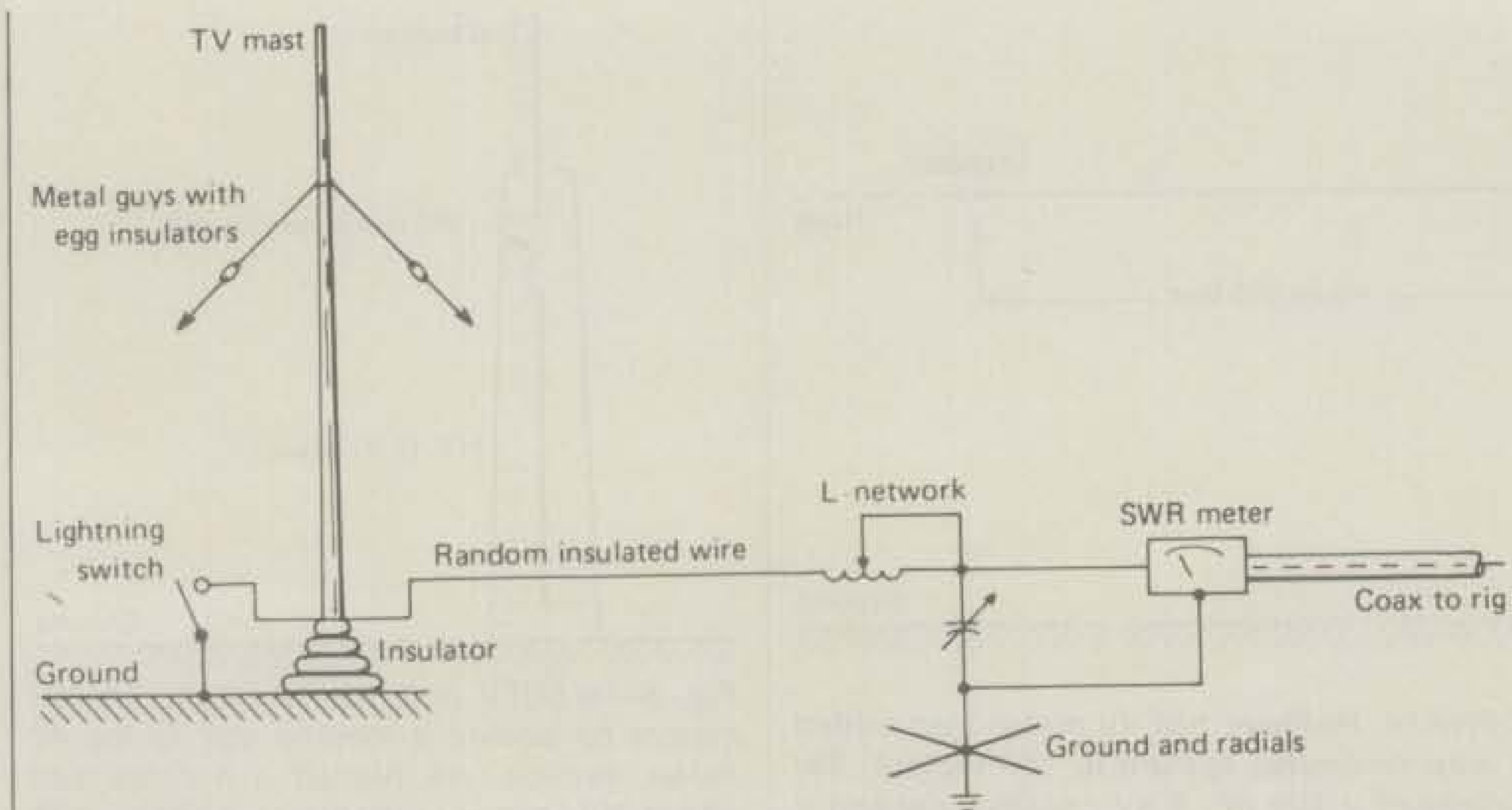


Fig. 7—The super-simple end-fed antenna of K0ILS. Chuck uses a 40 foot TV mast insulated from ground and attached to the side of his house. An insulated wire runs to an adjustable L-network at the station. Antenna, plus lead-in wire forms random length antenna which works well on all high frequency bands. A lightning switch shorts the antenna to ground for protection during heavy lightning storms. A second set of guy wires may be necessary in windy areas.

10 meter resonance of the antenna shifted about 100 kHz. The tower is used with several random 125 foot radials, plus a ground rod, for good DX on 160 meters".

"Man, his Karma is *really* heavy!!", said my friend.

"Glad you like it", I responded. "As long as we are discussing "Hi-Tower" antennas, here's another 160 meter modification worked out by Al, W5UTV. He modified the 75 meter portion to work on 160 meters by placing a loading coil at the top of the tower section, connecting it between the upper pipe and the vertical wire running down to the feed point, as shown in fig. 5.

"The coil is a surplus one, about 3½ inches in diameter and 16 turns per inch. A *Millen* grid-dip meter was used at the base of the tower to resonate it to 1805 kHz. The vertical wire is tapped on the coil with an alligator clip — a copper plated one! The tower can be resonated to any point in the 160 meter band and to any point in the 80 meter band, phone or c.w., by merely moving the clip about.

"Al also experimented with the coil at the bottom of the vertical wire

Band	Radial ground wire length (ft)
169	136.0
80	68.0
40	34.0
20	17.0
15	11.5
10	8.5

Fig. 8—Radial ground wire lengths for high frequency bands. Make radial of insulated wire and tape free end to prevent contact with wire.

at ground level. The alligator clip is merely attached to the center conductor of the coaxial line, which is tapped along the coil for lowest s.w.r. reading on the line.

"For a ground return, W5UTV uses eight ground rods around the tower, plus eight 130 foot radials made of copper wire scrounged from an old, burned-out pole transformer (free). Al's running 160 watts and has worked 4 continents and 47 states with this antenna. Not bad at all, I say".

"That's right", agreed Pendergast." It sounds as if a modified "Hi-Tower" is a pretty good antenna for 160 meters.

"Let's go to the other end of the h.f. spectrum", I suggested.

"I received a note from Bob, K4-HTU, telling me about the four element Quad beam he built for 10 meters. It cost him about twelve dollars for everything. He made the elements of surplus #12 enameled wire. The boom is fourteen feet long and was made of 2-inch diameter irrigation tubing. Since Bob had this at hand, he didn't include it in his cost, so another amateur duplicating the antenna would have to spend money for the boom. In any event, the spreaders are made of ½-inch PVC (Polyvinyl Chloride) 315 psi water pipe. It makes a snug fit over ½-inch electrical steel wall conduit.

"Each Quad assembly is made up of two arms, each composed of two 6-foot sections of PVC plastic pipe pressed onto a three foot length of metal conduit. This makes an arm about 13′6″ long. The two arms are cross-mounted on a 9″ square aluminum plate (fig. 6) by means of U-bolts. The aluminum plate has a right-angle surface on one side that supports a second U-bolt which acts as a boom clamp.

"Spacing between elements is about 4′6″. The PVC pipes are easily drilled to pass the wire loops and the pipes can be pressed outwards from the center plate to place tension on the wires."

"How does Bob feed the Quad?", asked Pendergast, as he started to sketch the antenna in his notebook.

"He uses a simple Gamma match", I replied. "The driven loop is off-center fed by a gamma wire, spaced about 2 inches below it. The wire is about 20″ long. A series-connected 100 pF capacitor resonates the match, and an adjustable shorting bar drops it into resonance at the chosen center frequency.

"Bob is very pleased with the beam's performance, even though 10 meters isn't exactly hot these days. I'll bet he can't wait until the sunspot cycle starts to go up".

"Really great", said my friend. "It's just about the simplest beam I've ever seen".

"Well, the prize for the simplest antenna goes to Charles, K0ILS, I think. Look at this drawing he sent me (fig. 7). This is a simple, end-fed vertical antenna that takes up a minimum of room and works on all bands from 160 to 6 meters.

"All it is is a 40 foot TV mast insulated from ground and affixed to the side of the house. It is base-fed, with a single wire that runs to a simple L-network located at the transmitter. Charles uses a length of insulated wire as it is "hot" with r.f. He brings it in through a window to the matching network.

"The antenna is mounted on a surplus porcelain insulator found in the junk yard. The guy wires are insulated from the vertical with egg insulators and are broken up every 10 feet. Finally, a heavy duty knife switch — also a surplus item — is mounted at the base of the vertical to short it to ground when the antenna is not in use. This, of course, is for lightning protection. The antenna is made up of low cost TV mast sections *(Radio Shack 15-5067)*.

"This antennas works as a random length single wire, if you want to call it that. It requires a good ground at the L-network. The ground can be a combination of ground rods and radial wires."

I turned to Pendergast. "Are you sure what a radial ground wire is?"

My friend gulped and said, "I guess so. I've used one".

"A radial ground wire is an extremely handy thing, regardless of what type of antenna you are using. At the very least, it will get the r.f.

off the equipment and reduce audio feedback. This is very important if you are using speech processing. Many fellows look askance at speech processing because they haven't been able to get it to work. Too much r.f. in the shack causes feedback and upsets the operation of the speech processor.

"A radial ground wire establishes an r.f. ground point at the transmitter. All that is required is a quarter-wavelength wire attached to the ground point of the equipment. The chart of fig. 8 gives representative lengths. Simply cut a ground wire for the band you operate on. Use insulated wire, as the ground wire can be somewhat "hot". Tape the far end of the wire so it can't be touched. Then lay out the wire away from the equipment. You can run it around the baseboard of the room, out the window and along the ground, or wherever it is out of the way. Try and keep it at least a foot above ground, since it is a tuned wire and can be detuned by touching ground.

"Since the wire establishes a quarterwave resonance, the end of the wire is at high potential and the end attached to the equipment is at ground potential. The amount of r.f. at the end of the radial wire is a function of the amount of r.f. floating around the equipment. The wire, in effect, transfers the r.f. from the shack out to the end of the wire, leaving the equipment "cold".

"How about when you operate on more than one band?", asked Pendergast.

"Add a ground wire to the transmitter for each band", I replied. "I had a terrible time getting rid of r.f. in the shack on 20 meters until I hung a 16 foot ground radial on the transmitter. I ran it back of the bookcase and around the room. That cooled everything off".

"That's great", laughed my friend. "I can't think of a better cure for less money than that!" ■

WILLIAM I. ORR, W6SAI, ON

Antennas

"What in the world are you doing?", I asked. Pendergast seemed to be half-buried in a collection of books. A large atlas was open on his desk and he was studying it intently.

"Well," he replied, "I'm just looking for new countries. Things have stagnated. The DXCC Honor Roll has over 500 stations in it and the 5-band DXCC Award has over 480 stations in it. Awards that come that easy are garbage as far as I am concerned."

"Yeah?", I replied. "Do you have a better idea?"

Pendergast looked up from the atlas. "No, I don't," he said. "But I think I have discovered a few new "countries" that would get things moving off dead center."

"What are they?", I asked eagerly.

"Well, first of all, how about *Krusenstern Rock*?", Pendergast asked, then proceeded to answer his own question. "This mini-atoll is about half-way between Kure Island and Johnson Island, south of the Hawaiian Islands. That seems like a good candidate for a DX-pedition. Second, how about *Kahoolawe Island* in the Hawaiian group? That's under the control of the U.S. Navy, in the same manner that Midway Island is." He paused, then continued. "The only problem is that Kahoolawe is used as a bombing target. That makes things a little uncomfortable. But, still, the island *isn't* under the jurisdiction of the government of Hawaii."

*48 Campbell Lane, Menlo Park, CA 94025.

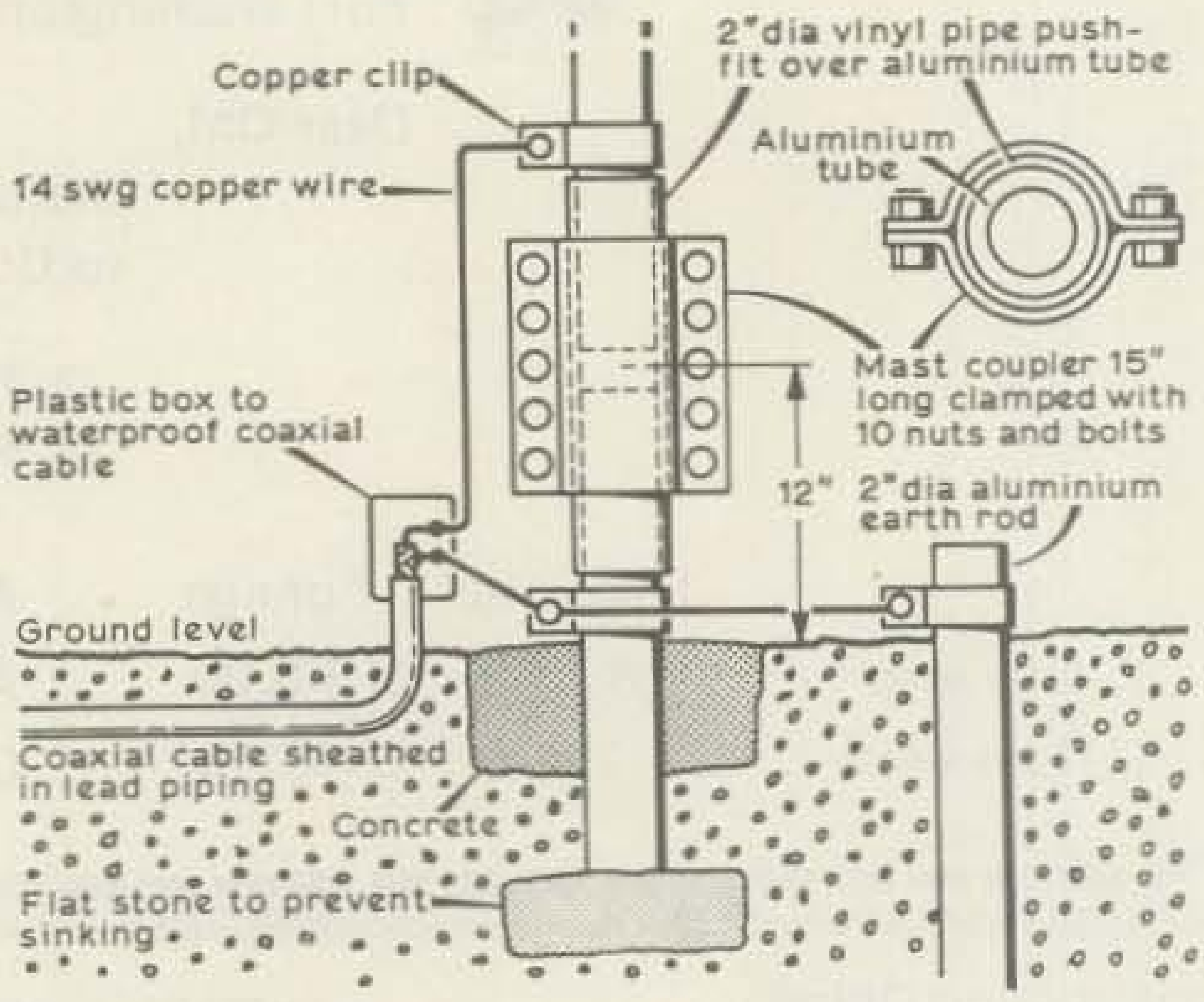


Fig. 2—Base support for the G3NGD vertical antenna. Outer braid of coaxial line is grounded to mast support and multiple ground rods. Base insulator is a clamp made of PVC material.

"Very interesting," I remarked. "Any other great ideas?"

"One more," said my friend. "How about the *Austral Islands*? They are far south of Tahiti, but still part of French Oceania. The great distance between Tahiti and the Austral Islands is the same situation as Clipperton Island. All use the FO8 call letters."

"Well, you may have something," I said. "All you have to do is to convince the "country-creators" that you have a legitimate case."

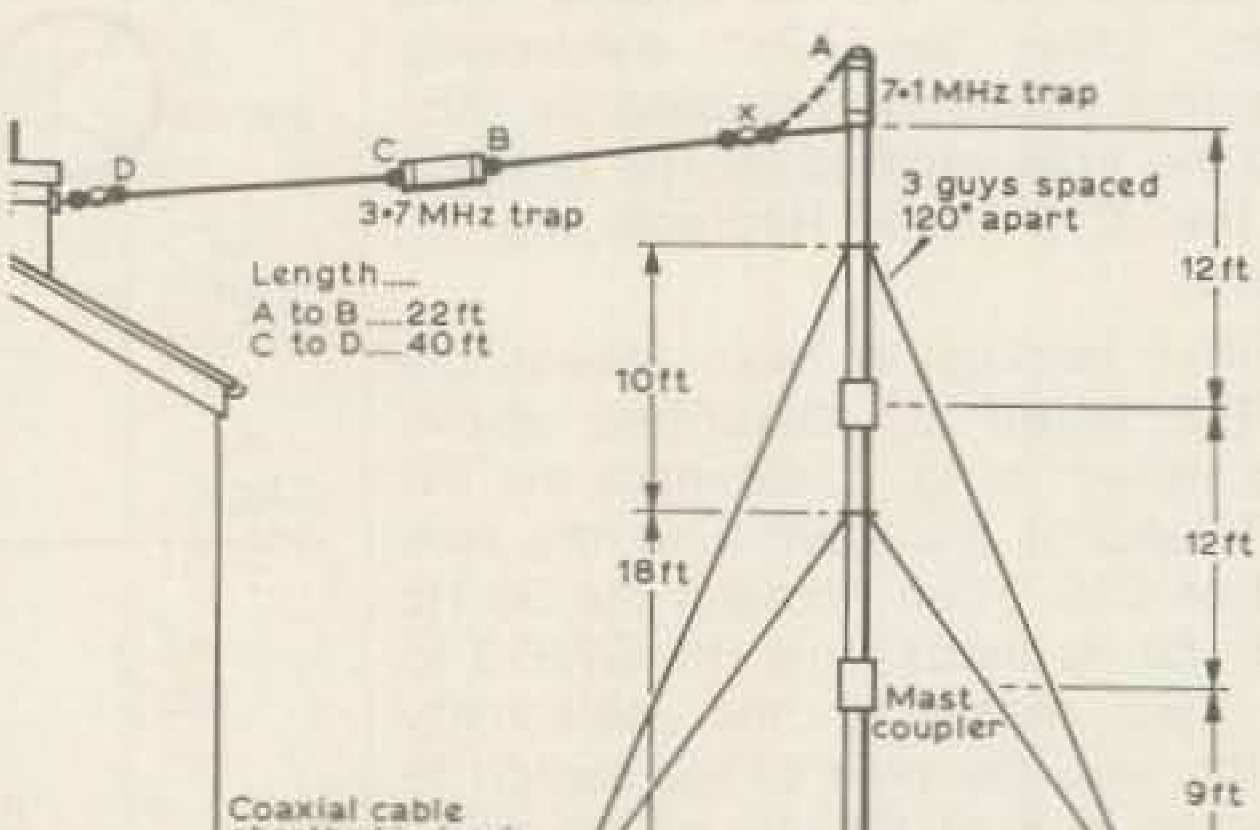
Pendergast sighed. "That'll be the day." He paused, then closed the atlas with a snap, pushing the other books to the corner of his operating desk. "Let's talk antennas," he said. "I'm sure that'll be more productive."

I reached into my jacket pocket. "Have you seen the August issue of *Radio Communication*?", I demanded. "That's the publication of the Radio Society of Great Britain (RSGB). You really should subscribe to it[1].

"Well, G3NGD describes a compact semi-vertical trap antenna for 160, 80 and 40 meters that should be of great interest to those amateurs who haven't much antenna space. The basic antenna is a 33 foot vertical for 40 meters (fig. 1). A 40 meter trap is placed atop the mast, with an wire section (A-B) run off for 80 meter operation. An 80 meter trap (B-C) and an extra section of wire (C-D) provide 160 meter operation.

"The antenna is operated against

Fig. 1—The G3NGD semi-vertical antenna for 40, 80 and 160 meters, as shown in "Radio Communication", the publication of the Radio Society of Great Britain. A 33 foot aluminum mast serves as a vertical antenna for 40 meters. At the top of the mast a 7 MHz trap is mounted and a wire outrigger (A-X-B) tunes the antenna to 80 meters. A second trap, tuned to 80 meters, and an outrigger (C-D) provide resonance for 160 meters. The coaxial cable is run underground to the mast and multiple ground rods are placed near the base of the mast.



[1]Radio Society of Great Britain, 35 Doughty St., London WC1N 2AE, England

ground; multiple ground rods are used. In addition, the coaxial line is run through a section of metal pipe which is buried beneath the ground and used for a ground connection.

"The vertical antenna is made of three sections of 2-inch diameter aluminum tubing. The antenna is supported on a base insulator and is bolted to a section of aluminum pipe held vertically in the ground with concrete (fig. 2). About one foot of the pipe protrudes above ground and a mast coupler is used to mount the antenna to the pipe. The base insulator is a section of PVC plastic pipe pushed over the aluminum tubing. Since this is a low potential point on all bands, the insulation is adequate.

"Although it is not suggested in the article, it is a good idea to wrap the pipe with black vinyl tape to prevent corrosion beneath the ground."

"Very good!", exclaimed Pendergast, "Now, how about the traps?"

"Well, the 40 meter trap is mounted atop the vertical antenna," I replied. "It is quite heavy. The coil is wound with 20 turns of insulated wire, 1½ inches in diameter and on a six inch long form. The capacitor is a 50 pF, 3 kV unit. The trap is dipped to 7.1 MHz before it is installed on the antenna. Fig. 3 gives you details of the trap.

"A vinyl sleeve is passed over the trap to make it waterproof and a Fiberglass end-cap keeps moisture out of the top of the trap. A connection to the top end of the trap is made through the cap to a clamp which holds the loading wire (A-B) shown in fig. 1. A bottom end-piece is turned from a fiberglass or wood block to make a slip-fit into the aluminum tube of the vertical antenna.

"The 80 meter trap (B-C) is similar to the 40 meter one and is shown in fig. 4. The coil is 40 turns of #20 wire, spaced out the wire diameter. A 75 pF, 3kV capacitor is used to resonate the trap to 3.7 MHz. The resonant frequency is adjusted by adding or subtracting the number of turns on the coil."

"Right," exclaimed Pendergast, as he copied the information in his black notebook. "What about the 160 meter extension?"

"The 80 meter extension is 22 feet of wire and is not too critical. The 16 meter extension (C-D) is 40 feet long and is quite critical. The length is trimmed to give the lowest value of s.w.r. at the chosen operating point in the 160 meter band."

"Very interesting," said Pendergast. "This antenna should appeal to the low band enthusiasts who don't have much antenna room in their back yard!"

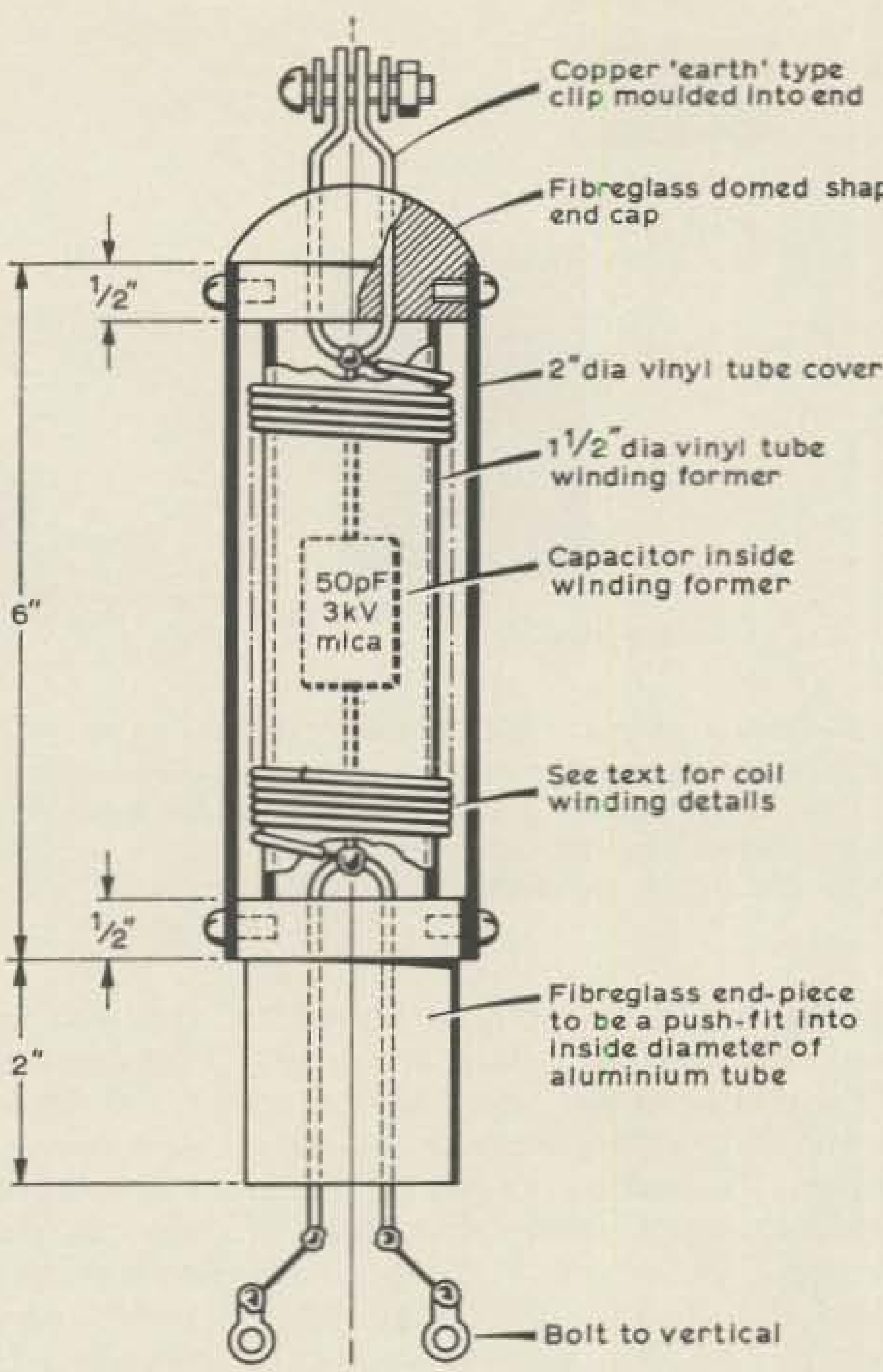


Fig. 3—Details of 40 meter trap. The trap is wound with 20 turns of #16 insulated wire. Before the cover is put on, the trap is dipped on the bench to 7.1 MHz. Turns are adjusted to achieve resonance. A Centralab 5 kV ceramic capacitor may be used for high power. Top of trap has a mechanical clamp to which the outrigger wire is attached.

I pointed to some papers on the table. "Here's some items of interest that came in the mail," I remarked. "A note from Temp, W9YLD, who says that his friend DL3UT/W9 in Chicago had a perplexing antenna problem. He wanted to work his friends in Germany, but lived in an apartment where antennas were *verboten*. The apartment was on the second floor, in a brick and frame building. The solution was to erect a single Quad loop for 15 meters, fed by a gamma match in the lower wire The loop was mounted directly to an outside wall of the building, but on the *inside* of the wall. No one could possibly see the antenna from the outside and it worked quite well. It was not quite square, because of the floor to ceiling height, but it radiated and DL3UT/W9 was able to keep his schedules with Germany, despite the fact that the orientation of the loop was not quite on Europe.

"Temp and DL3UT/W9 next tried a horizontal Quad loop, made of #20 wire, laid right out on the rug of the living room, held down on the corners by books! It had a gamma match, like the other antenna. The first call resulted in a nice QSO with a station in New Orleans, who said—when told about the haywire antenna —"just turn the rug and you have a rotary antenna-HI."

"A great idea!", laughed Pendergast. "You can do a lot with indoor antennas in those buildings which do not have steel frames. You may have to move your antenna about to dodge resonances in the electrical wiring,

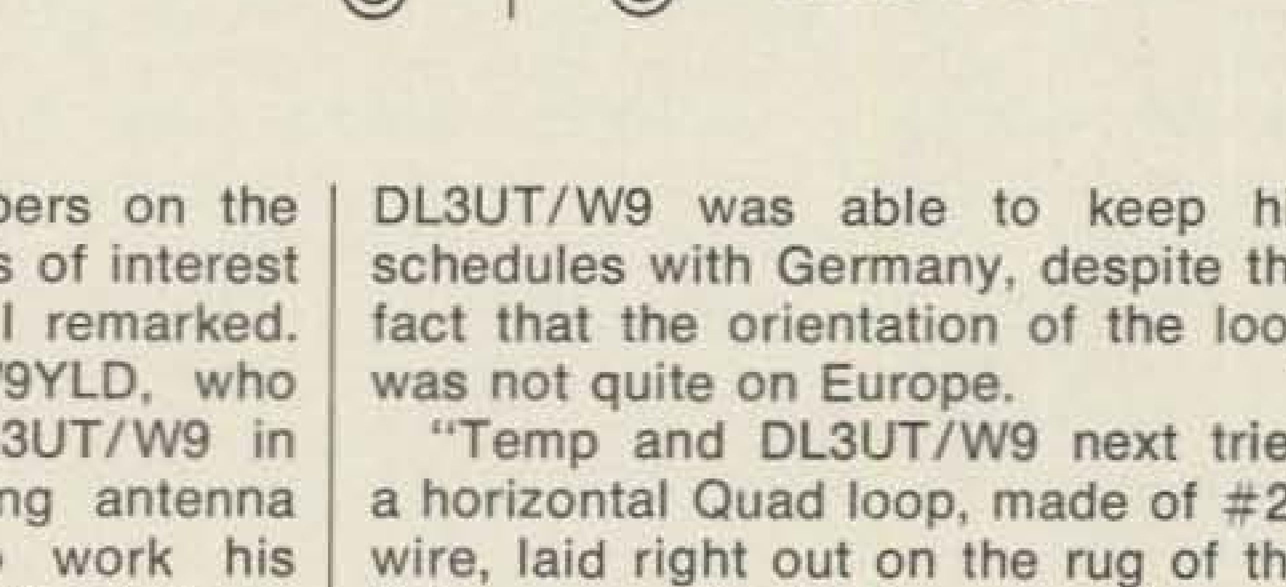


Fig. 4—Details of the 80 meter trap. The trap is wound with 40 turns of #20 enamel wire, spaced out the wire diameter. A Centralab 5 kV capacitor (or two capacitors in parallel) may be used in place of the mica capacitor shown. Turns are adjusted to achieve resonance at 3.7 MHz. Heavy duty lugs are used for terminals. (Photos courtesy of "Radio Communication").

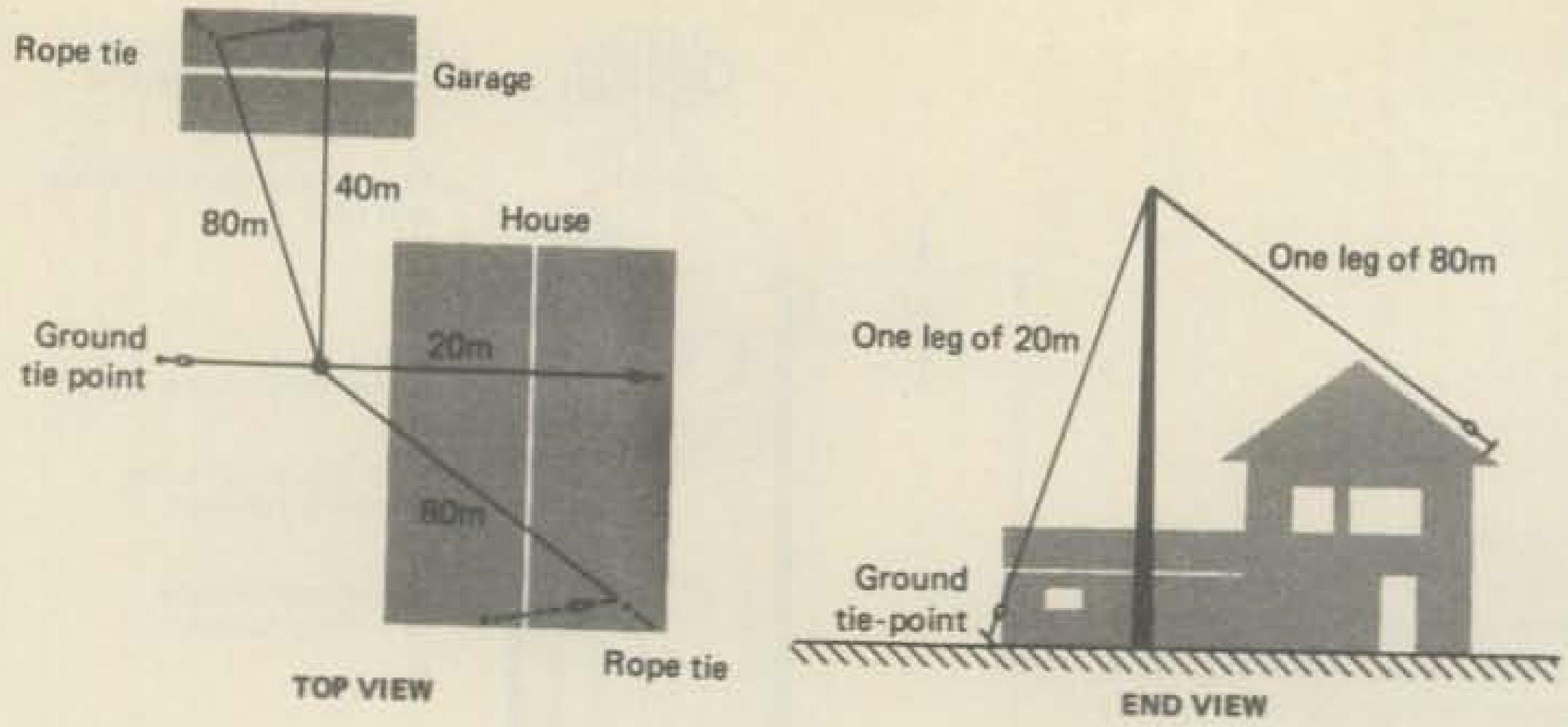


Fig. 5—Details of WA1Y-UZs antenna installation in a housing complex. A TV mast is used for support and is mounted close to the wall of the building. The top view shows the layout of the three dipoles, which act as guy wires for the mast. The end view of the building shows how the 20 meter dipole acts as a back guy for the mast. The three dipoles are fed in parallel at the center insulator which is held up by a rope and pulley arrangement.

or pipes, but it certainly is possible to work DX with an indoor antenna!"

"It's tough, when you live in an apartment, condominium or housing complex. In most cases the landlord, or homeowner's association take a dim view of amateur radio. They equate it with TVI and stereo interference. And the argument that a good, high antenna—away from the building—will cause less interference than one in close proximity to the house wiring, television sets and stereo equipment usually falls on deaf ears."

"Well, Woody, WA1YUZ, had the same problem," remarked my friend. He lived in a duplex in a small housing complex. Space for antennas was quite limited as the yard was small, and power lines ran along the street. He was lucky enough to get permission to erect an outdoor antenna, so he put up a multi-band antenna composed of dipoles for 80, 40 and 20 meters. They were connected together at the feedpoint and fed with a balun. Since it was difficult to attach anything to the building, Woody erected a 40 foot TV mast at the side of the building. A rope and pulley arrangement on the mast permitted him to hoist the center insulator of the multi-band dipoles to the top of the mast (fig. 5).

"The 80 meter dipole runs across the duplex roof and over to a corner of the garage. It is folded back along the far edge of the garage roof, and the opposite end has a dog-leg in it, too. The 40 meter dipole portion of the antenna runs parallel to the face of the duplex and is tied off at one end to the garage roof and at the other end to the duplex roof. The 20 meter dipole runs at right angles to the other two and sort of serves as a set of guy wires to stabilize the 40 foot mast.

"The 80 meter dipole has a bandwidth of nearly 400 kHz between the 2-to-1 s.w.r. points and the 40 and 20 meter dipoles are cut for 7.05 MHz and 14.05 MHz, respectively."

"Aha, Woody is a c.w. operator," exclaimed Pendergast.

"It seems so," I replied. "In any event, he feeds the tri-band antenna with RG-58/U coaxial line. The whole antenna system can come down in seconds for Field Day use, or for repairs. And while the radiation patterns can only be guessed at, Woody seems to be able to work good DX in all directions, as well as short-haul rag-chewing."

"You can't keep a good man down," remarked Pendergast as he stretched luxuriously. "The only thing better than a dipole is a good beam!"

"Yes," I agreed, "But you would be surprised at the relatively large number of amateurs that can't erect a beam because of housing problems. And the number will grow, as more and more families choose to live in multiple unit dwellings."

I reached into a pile of literature on the desk and drew forth a copy of *CQ-ham radio*, the Japanese publication.

"Speaking of beams, you might be interested in this," I remarked.

"This is a field pattern plot of a well-known U.S.-made tri-band beam (fig. 6). The beam is fed directly with a 50 ohm coaxial line, with no balun between the line and the antenna. In

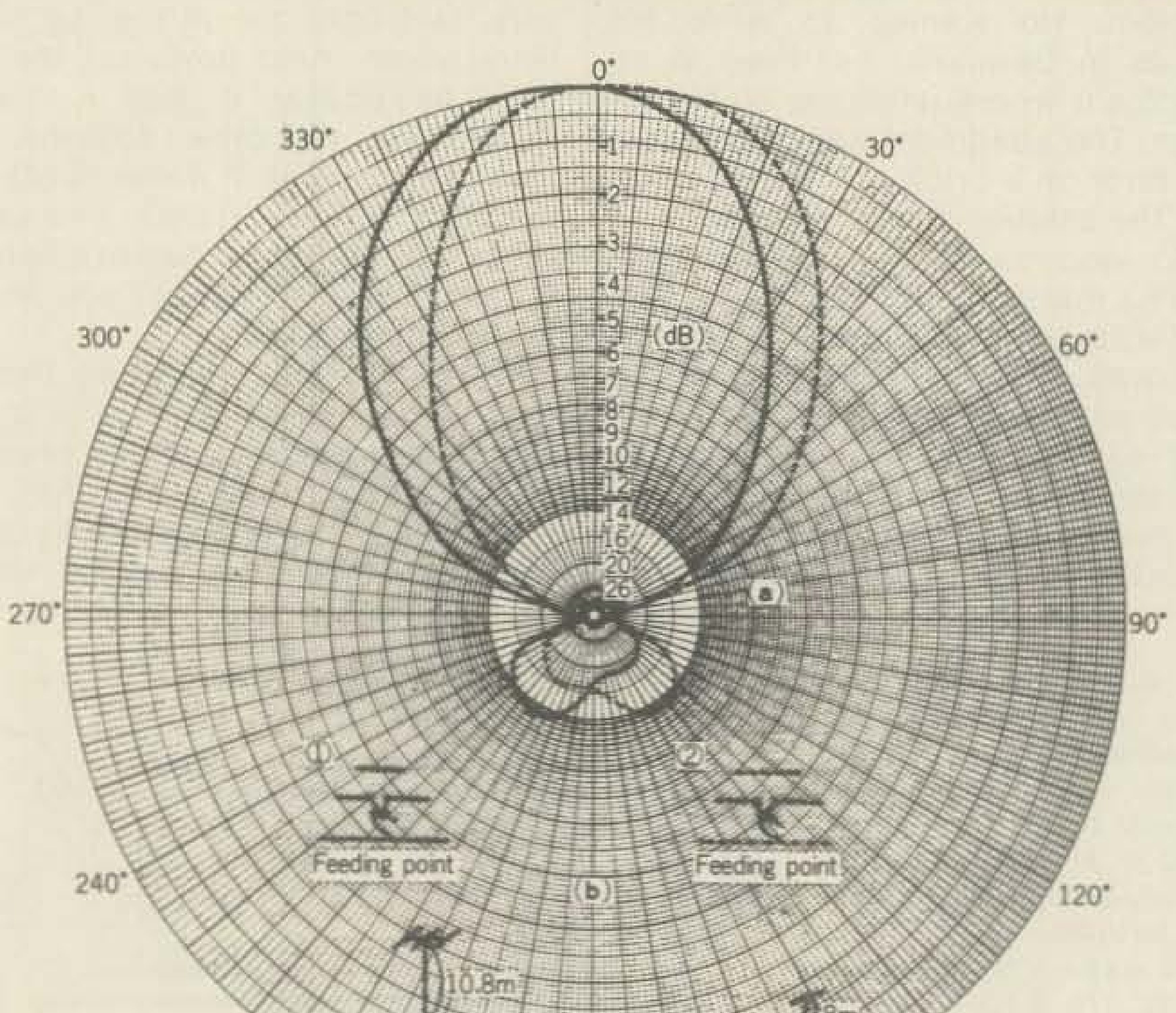


Fig. 6—Field pattern plots of triband Yagi beam the driven element of the beam is fed with a coaxial line. No balun is used. The beam pattern is deflected to the right or the left, depending which side of the driven element is attached to the center conductor of the coaxial line. While the "squint" is minimal, it shows that the beam reacts to the feed conditions. See text for details.

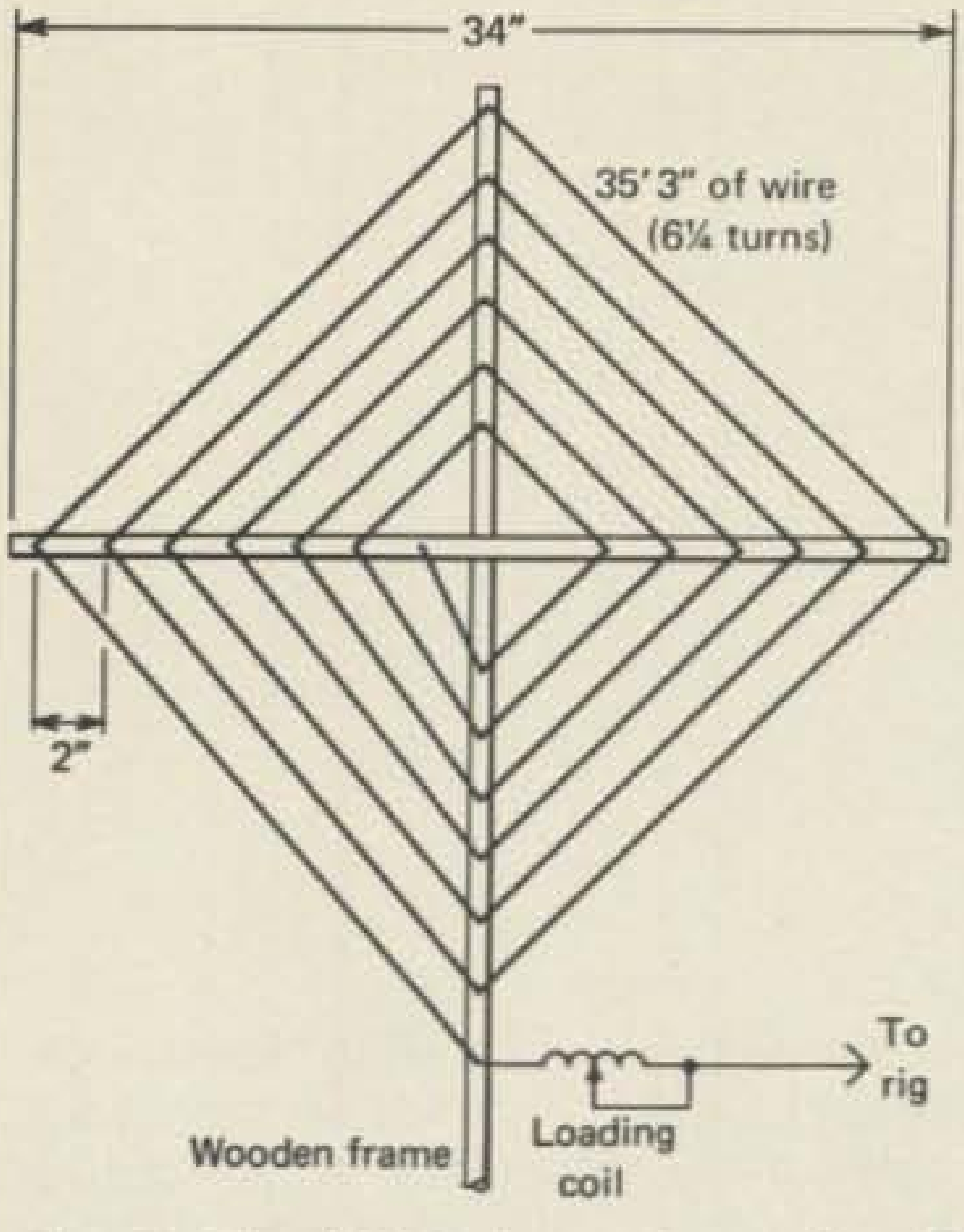


Fig. 7—The K4MD loop antenna for 40 meters is small enough to sit next to the operating table.

other words, no matching system, or balancing system is used at the antenna. Notice the plot! The beam pattern is slewed to the right, or to the left, depending upon how the coaxial line is attached to the antenna element of the beam. The solid line shows the pattern to be slewed to the left of center when the center conductor of the line is connected to the left-hand portion of the driven element. The reverse pattern (the dashed line) is observed when the center of the coaxial line is attached to the right-hand portion of the driven element.

"Some years ago KH6IJ made measurements on a 3-element beam and noted that the r.f. voltages were highest on the side of the beam that was fed with a gamma match. And that the voltages on the opposite side of the beam were much lower. Even so, he did not note any "squint" to the antenna pattern.

"However, these measurements made in Japan show a definite "squint" to the beam pattern when the feed is not symmetrical. In this case, the pattern is slewed to one side about eight degrees."

"That sounds like no big deal," remarked my friend. "The pattern of the antenna is broad enough so that in-line with the beam, there's no difference in field strength, regardless of which side of the driven element is fed."

"Agreed," I replied. "But this warns you that the pattern of a beam antenna can be a function of the feed system. In a high gain beam, such as used on v.h.f., the feed system can seriously disrupt the beam pattern. A good balancing device—a balun, or perhaps a T-match—or something like that can do a lot towards balancing the r.f. voltages on the driven element."

Pendergast said, "I've checked my beam pattern many times and I can't notice any "squint" in it."

"Perhaps not," I agreed. "But the problem can exist, so it is good to know about it."

"Just to change the subject, what do you think of the loop antenna that K4MD is using?", asked my friend.

"Very interesting," I replied. "It looks like a long wire wound up on a frame (fig. 7). Harvey says it is an adaptation of an idea he got from W8OHM. K4MD has only used it on 40 meters so far and has had good results. The loop antenna sits on a table adjacent to his operating position, which is on the ground floor of his home. And with 70 watts into the antenna he's had good contacts all over the eastern part of the U.S. in the early evening hours."

"Did he notice any directional effects?", asked Pendergast eagerly.

"He didn't say," I replied. "The antenna's only been up for a day or two. Resonance is established with a series inductor in the lead to the transmitter. A good ground connection is used on the equipment. And with a 18-turn variable inductor, Harvey hit a 1.5-to-1 s.w.r. with ease. And I would imagine that he could get even a better match if he used an L-network between the loop and the transmitter."

"Small antennas like this are easy to build and a lot of fun to play with," remarked Pendergast. "While this 'sn't a loop, in the true sense of the word, it is certainly a design that demands more study and evaluation. I'd like to try this thing with some loading at the end of the wire. Maybe a capacity hat, or something like that. I think I would feed it at the center point and have the end of the wire on the outside of the loop. Then I could try end loading. And possibly use two loops, working against each other, like the halves of a dipole. You could rotate them independently, or perhaps have one placed horizontally and the other vertically. . . ."

"Hold on!", I interrupted. "You've got enough ideas to keep you busy for a year! When are you going to have the time to do all these good things?"

"I don't know," replied Pendergast ruefully. "I guess it's more fun to *think* about antennas than it is to build them and try them out."

"You'll make a lot less mistakes if you only think about them," I replied. "But you won't have nearly as much fun." ■

a monthly feature by

WILLIAM I. ORR, W6SAI

Antennas

Design, construction, fact, and even some fiction

"**Y**ou look like *The Great Waldo Pepper*", I remarked as Pendergast leaned his *Moped* cycle against the wall of his shack and removed his World War I aviator goggles. He had a brown ring of dust around his eyes and mouth.

"How do you recognize a happy motorcyclist?", he asked.

"I don't know. How?", I replied.

"By the bugs on his teeth", replied my friend, with a roar. "Come on into the shack and see what the mailman brought me today".

I followed the World War I aviator into the radio room and he picked up a fat envelope and handed it to me, removing his jacket at the same time.

"It's from Tommy White, the last of the Red Hot Antenna men!", I exclaimed. What is this rascal up to now?"

Pendergast bent over the desk and examined the letter closely.

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"Well", he exclaimed, "It looks as if K3WBH has come up with a two-band log periodic beam for 144 MHz and 432 MHz. Wasn't he the inventor of the *Whirling Bedspring Beam,* commonly known as *18 dB and a cloud of chicken wire?*"

"The same", I replied. "Let me see his sketch (fig.1)." I looked at the drawing, and said, "Well, it is well known that certain antenna types operate well on the third harmonic of the design frequency. Since a three-to-one relationship exists between the 2-meter band and the so-called-¾ meter band, Tommy took advantage of this and built up a two-band array. Many amateurs are interested in both bands, but have neither the time nor the inclination to festoon their QTH with beams for every band. So this looks like the ideal solution for the two meter operator who occasionally works 432 MHz.

"The basic design is a 2-meter log-periodic beam which has an auxiliary set of directors for the 432 MHz band. Tommy estimates the gain on 2-meters to be about 11.5 dB over a dipole, and about 15.5 dB over a dipole on 432 MHz. Most important, however, the bandwidth without significant deterioration in either gain or s.w.r. is 3 MHz on the 2-meter band and 9 MHz on the 432 MHz band.

"Very clever", said Pendergast, as he examined the drawing.

"Tommy says that the four directors for the 2-meter beam acts as 3/2-wavelength directors on 432 MHz. And to maintain proper director-to-director coupling on the 432 MHz band, additional half-wavelength directors are mounted in between the larger directors", I said.

Pendergast read from the letter, "The beam is built on a ¾-inch square aluminum boom, nine feet long. The parasitic elements for 2-meters are made of ⅜-inch diameter aluminum tubing and the parasites for 432 MHz

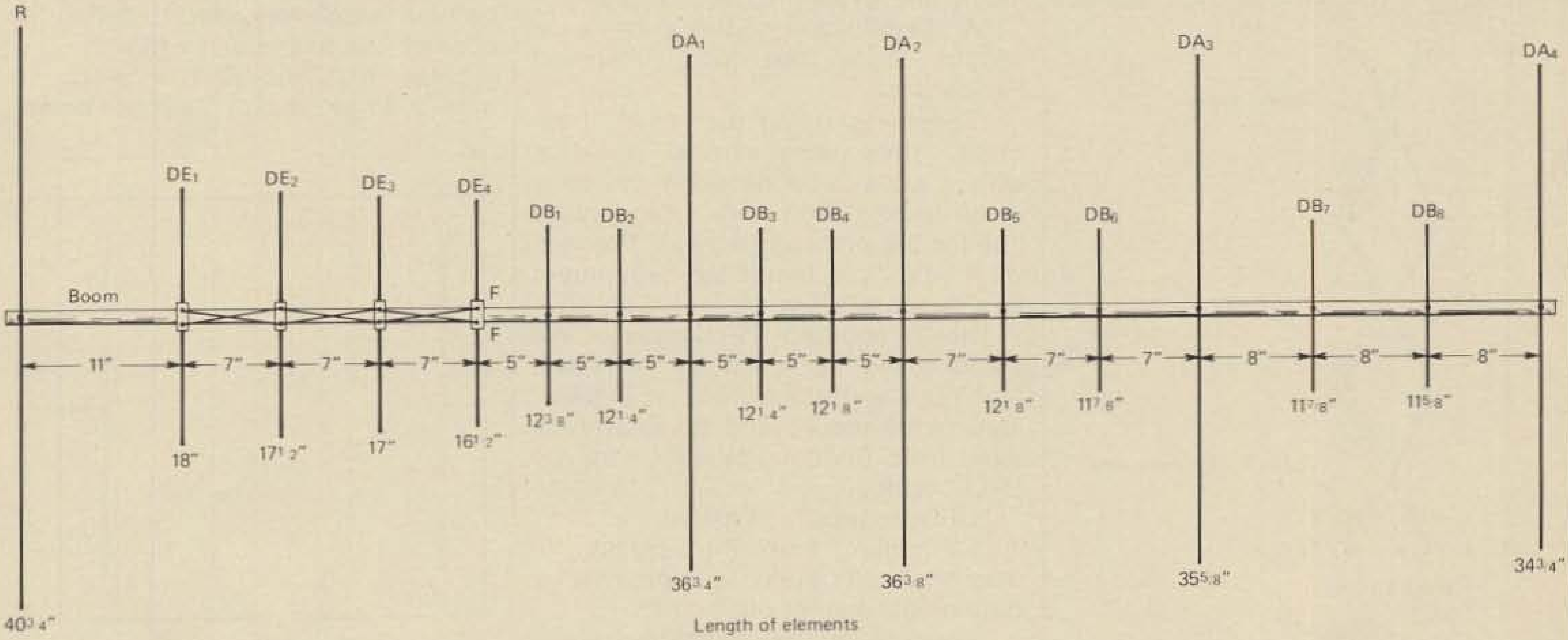

Fig. 1—The two-band VHF beam of K3WBH. This interesting version of the log-periodic yagi antenna provides superior gain on both the 144 MHz and 450 MHz bands. It is built on a 9 foot boom made of ¾"-square aluminum tubing. The 2 meter elements are made of ⅜"-diameter tubing and the 450 MHz elements are made of ¼" aluminum rod. All elements are mounted atop the boom with tubing clamps. Do not run the elements through the boom. Number 8 aluminum wire is used for the criss-cross connections for the driven elements (DE-1 through DE-4). Spacing between the inner tips is 2 inches. The antenna is fed with TV "ribbon" line at points F-F.

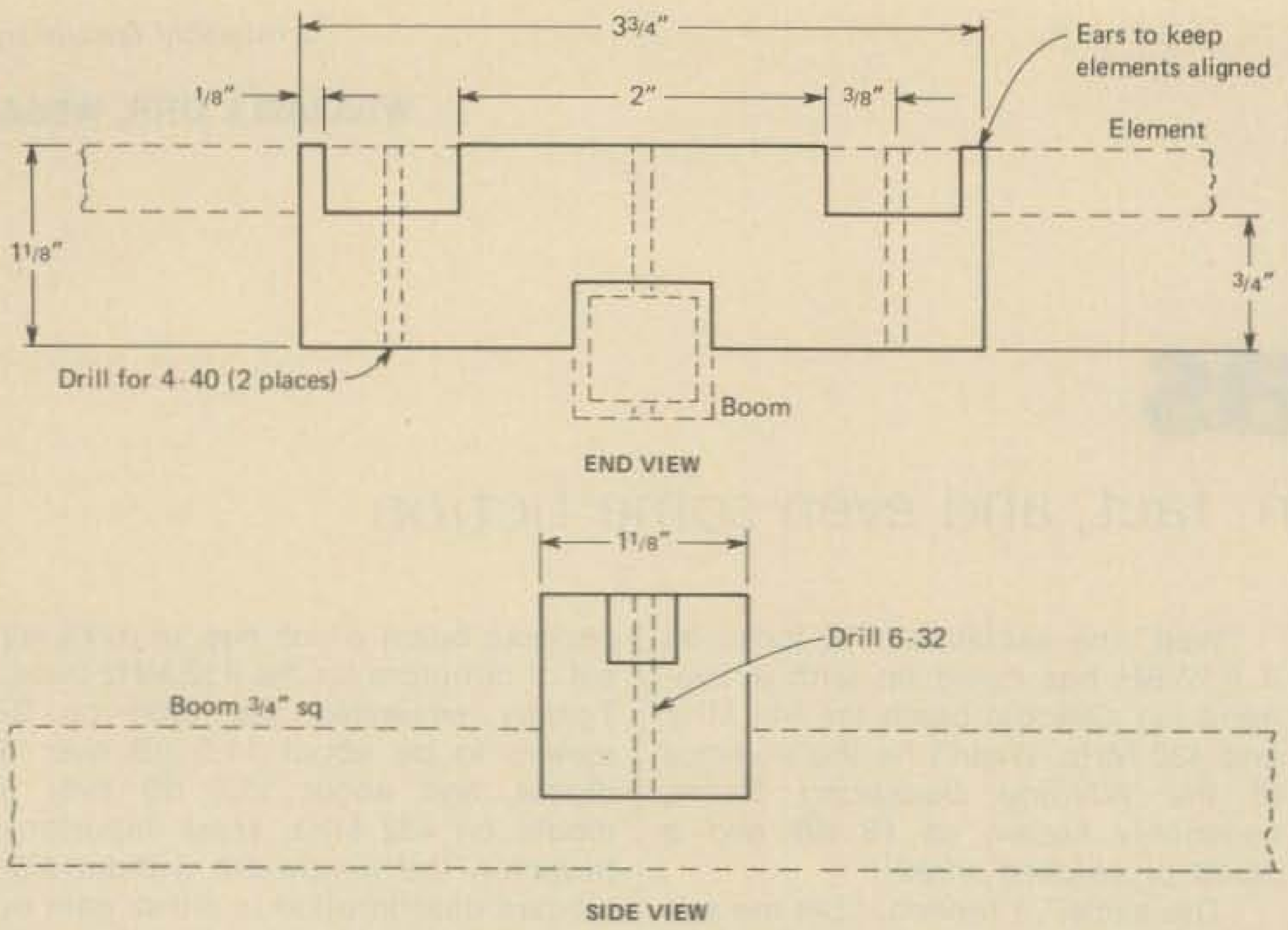

Fig. 2—The log-periodic elements (DE-1 through DE-4) are mounted on insulating blocks (four required). The blocks can be cut from cycolac, phenolic or other good v.h.f. insulating material. They are drilled so they may be attached to the boom with a 6-32 bolt. The element is held to the block with additional 4-40 bolts.

are cut from ¼-inch aluminum rod. The elements are mounted atop the beam with tubing clamps. The log-periodic elements are mounted on saddle blocks made of *cycolac*® or other insulating material (fig. 2). Number eight aluminum wire is used for the criss-cross feedline for the log-periodic section. Short lengths of plastic tubing are slid on the phasing line at the cross-over points before

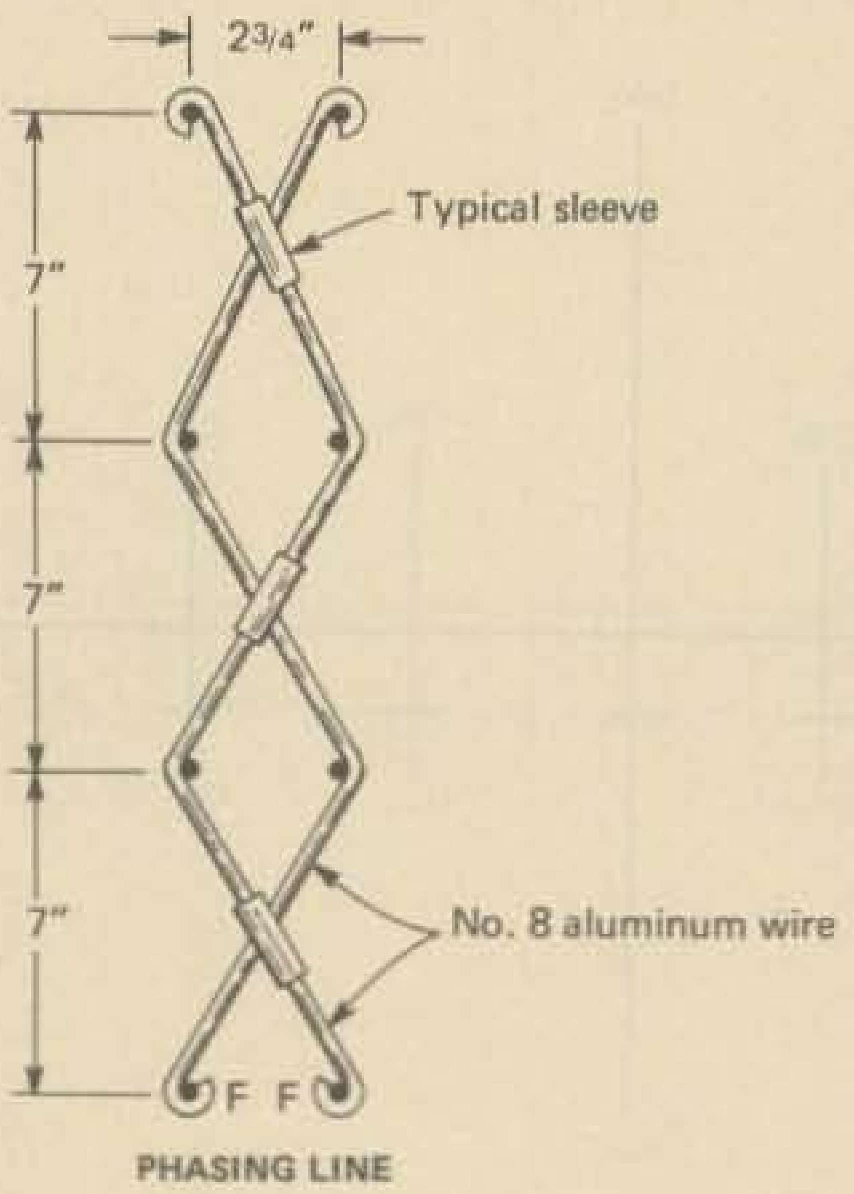

Fig. 3—The feedline for the log-periodic array is made up of #8 aluminum wire. The inner tips of the driven elements are drilled for 6-32 bolts. Spacing between the bolts is 2¾". Insulated sleeving is passed over the line to prevent shorts at the crossover points.

assembly to prevent contact between the wires (fig. 3)".

"What about feeding the antenna?", asked my friend.

"Well, the antenna can be fed with 300 ohm TV-type line. But Tommy recommends open-wire "ladder line" if much 432 MHz operation is contemplated. A four-to-one balun, of the type shown in the various v.h.f. handbooks, can be placed at the station end of the transmission line to match the system to 50 ohms".

"A stacked pair of these antennas should do a nice job", observed Pendergast.

"Tommy is trying that now", I replied. "He's using vertical stacking, with a separation between the bays of 80 inches. And he's using ladder line for the phasing harness. Perhaps we'll hear from him if the experiment is a success".

"Hey", shouted Pendergast. "We could make up an array of these, four high and eight wide on a steerable az/el mount and go after two-band EME (moonbounce)! Or maybe UFO bounce!"

"UFO bounce?", I asked.

"Certainly", said Pendergast. "If they are really there, let's prove it by bouncing a signal off them!"

"Pendergast, you amaze me sometimes", I said. "I like your class".

My friend squirmed in his chair and blushed slightly. "Let's talk about high frequency antennas", he said abruptly. "What do you have of interest?"

"Once again the RSGB magazine, "*Radio Communication*", has come through with some original thinking about high frequency antennas. In the October, 1976 issue there's an interesting article by G3YDX on the design of a capacity loaded mini-quad element for 14 MHz. He didn't have the space to erect a full size 14 MHz Quad, so a capacity-hat loading technique was applied to the Quad loop so that the overall size could be reduced to something less than 12 feet on a side (fig. 4)."

"How did G3YDX adjust the resonant frequency of the loop?", inquired Pendergast, as he produced his notebook from a pocket of his motorcycle jacket.

"He coupled a grid-dip meter to the drive point with a single turn loop and then adjusted the tips of the inner wires", I replied.

"Four bamboo spreaders, each eight feet long, were used to make up the framework," I continued. "The first arrangement, shown in fig. 4, showed resonance at too high a frequency. The final configuration—shown in fig. 5—hit resonance in the 20 meter band.

"When tested close to the ground, the loop compared with a ground plane antenna in many respects, except that it possessed a deep null in the plane of the elements.

"The next step was to build a parasitic reflector element. It was the same size as the driven element, but with a small, shorted stub added at the center of the bottom wire of the loop. The boom G3YDX used was an aluminum pipe about 8′6″ long. A gamma match was used to match the coaxial line to the array (fig. 6).

"How high did G3YDX place his mini-quad in the air?", asked Pender-

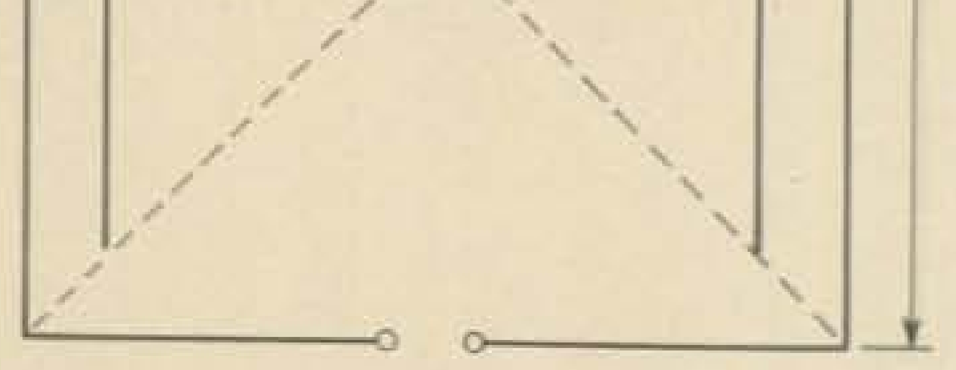

Fig. 4—The original mini-quad loop. Addition of the small "top hat" wires lowered the resonant frequency, but not enough to reach the 14 MHz. band. Loading wires were attached to the crossarms of the Quad assembly.

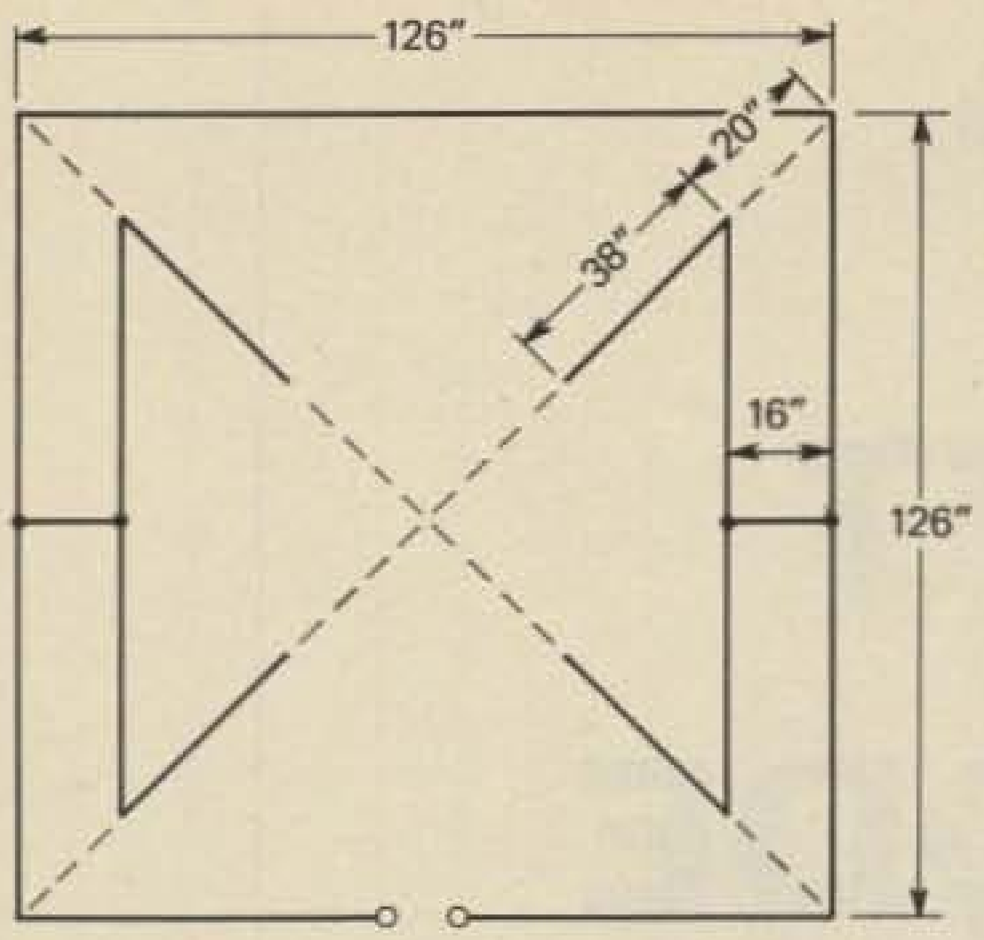

Fig. 5—Larger "top hat" wires permitted the mini-quad loop to resonate in the 14 MHz band. Connection to the quad loop is made at the center points of the sides. Loop is fed at the bottom.

gast, as he copied the illustrations into his notebook.

"Boom height was about 30 feet", I replied. "The quad was adjusted to resonance at 14,190 kHz then the stub was adjusted to provide the best front-to-back ratio. With a local station as a monitor, the best ratio turned out to be about 24 dB."

"That sounds pretty good to me", remarked my friend.

"Front-to-back readings can be misleading", I cautioned. "The front-to-back ratio of any beam can be affected by nearby objects, particularly when a close-in signal is used for test purposes. Reflection of the signal from hills or buildings can be misleading. I would much rather test front-to-back ratio on a DX signal, but that is a tough thing to do, considering the time it takes to rotate the array and the fading normally observed on DX stations".

"How about the bandwidth of the mini-quad?", asked Pendergast.

"Well, because of the reduction in size, the s.w.r. bandwidth of the array

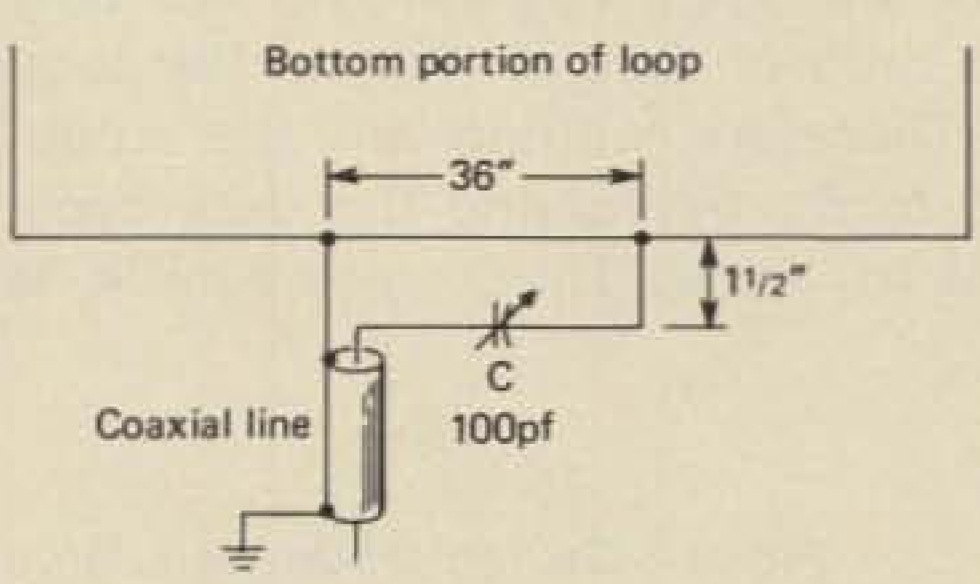

Fig. 6—Gamma match for the mini-quad loop. Gamma wire is 36" long and spaced about 1½" away from the loop. The series resonating capacitor is set at about 100pF.

is somewhat reduced. Look at fig. 7. The antenna exhibits a 2-to-1 s.w.r. bandwidth of better than 200 kHz. This is very good, considering the bandwidth of other so-called mini-beams. When adjusted to 14,190 kHz, the mini-quad will still operate at the c.w. end of the band. The front-to-back ratio is poor, and an antenna tuning unit is recommended, because the s.w.r. is rather high—above 3-to-1. Nevertheless, the beam still functions at 14.0 MHz.

"About the gain. A reduction in antenna size means a reduction in bandwidth, but it necessarily does not mean a reduction in power gain. It is very difficult to measure antenna gain without precise instrumentation and a good antenna range. However on-the-air tests run over a long period of time by G3YDX suggests that this mini-quad is within a half-decibel of the power gain of a full-size Quad antenna. G3YDX lists an impressive bunch of DX stations with whom he tried the mini-quad against his ground plane. The increase in signal strength on both transmission and reception is impressive. In most cases it amounted to an "S-unit", or better. And in one or two difficult, long skip contacts, it was the difference between a QSO and not being heard at all".

Pendergast continued to sketch the information in his notebook. He paused and remarked, "I would think that a mini-antenna of this type would be hard to tune up".

"Well, it is important that the elements be tuned carefully. With any miniature antenna, small changes in dimension, or in assembly, can cause rather large frequency changes in resonance. G3YDX mentions that bamboo poles, even when coated with varnish, are not very good insulators in wet weather and he suggests that fiberglass fishing poles should make much better insulators.

"The inner wire sections of the elements can be supported by nylon cord, or taped to the poles. Since this places the high voltage sections of the elements in very close proximity to the supporting structure, it can be seen that fiberglass poles would provide the best insulation."

"Well", said my friend, closing his notebook with a snap, "This is certainly an interesting antenna for the DX chaser who doesn't have much room to erect a good beam antenna. I like it!"

"One more item before you trot

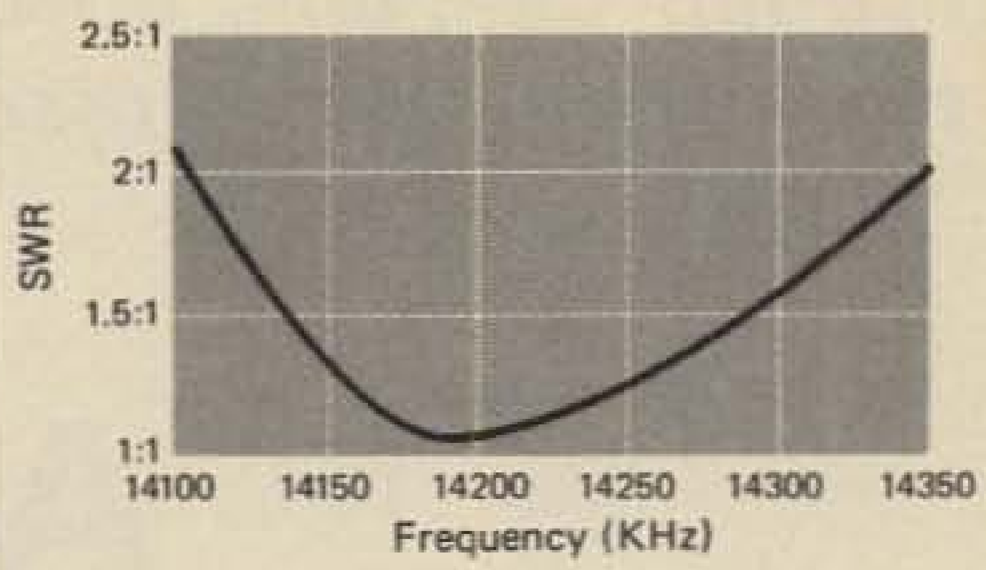

Fig. 7—Bandwidth response of the mini-quad beam. The bandwidth between the 2-to-1 s.w.r. points is better than 200 kHz. Reflector is spaced 8½' from the driven loop.

off", I said. "You might be interested in this new development from Amphenol (fig. 8). This is a quick-disconnect coupling ring for the common PL-259 coaxial plug. You remove the standard coupling ring from the plug and screw the new ring (Amphenol part number 83-693) onto the connecting body of the plug. Presto! You have a quick-disconnect plug that snaps on and off the standard SO-239 receptacle".

"What will they think of next?", murmured Pendergast, as he replaced his World War I aviator goggles and advanced towards his *Moped* cycle." Just the gadget for the happy CBer". ■

Note: Additional information on Quad antennas may be obtained from the handbook, *"All About Cubical Quad Antennas"*, by Willian Orr, W6SAI. Available from Radio Publications, Box 149, Wilton, CT 06897. Price: $4.75 plus 35¢ postage and handling. *"Radio Communication"* is a publication of the Radio Society of Great Britain, 35 Doughty St., London WC1N 2AE, England.

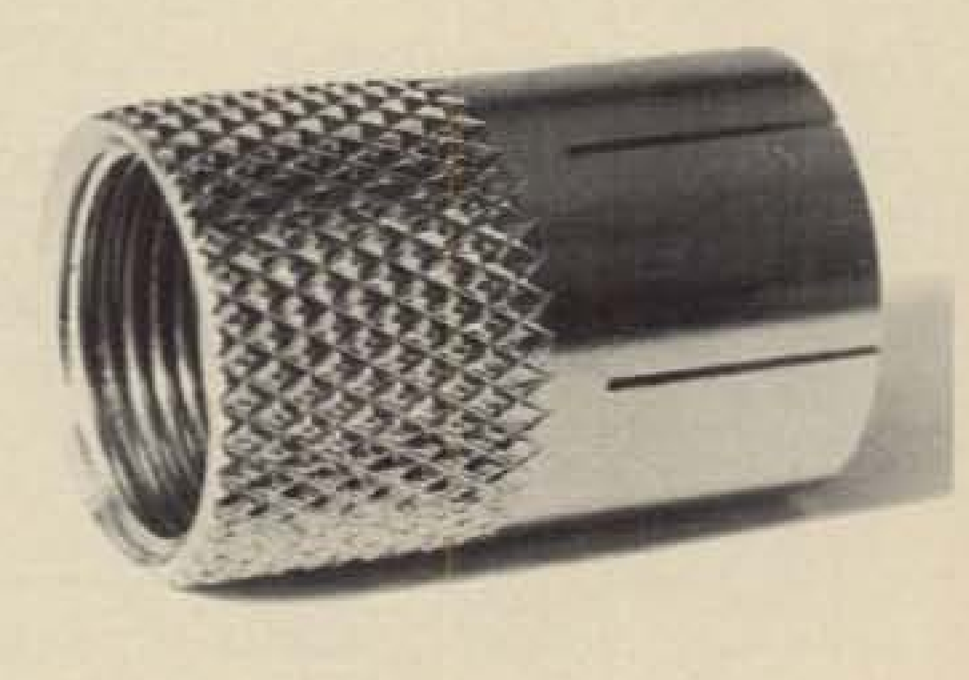

Fig. 8—The new Amphenol quick-disconnect coupling ring for the PL-259 plug. Designed to take the place of the existing ring, this new gadget provides a quick break-away for experimental work.

a monthly feature by

WILLIAM I. ORR, W6SAI

Antennas

Design, construction, fact, and even some fiction

Pendergast was sitting on the floor in front of his power supply rack. The red warning light was off, the safety switches had been thrown and a tangle of clip leads connected test meters with the inner circuitry partially hidden behind the large plate transformer. He looked up as I came in the operating room and waved a hasty greeting.

"Problems?" I asked, as I looked over his shoulder.

"Yep", he responded. "The 2 ampere circuit cutout in the six thousand volt supply isn't working. I can only draw about 1500 mills of plate current before it kicks out."

"Let's see", I mused. "Six thousand volts at fifteen hundred milliamperes is . . ."

"Only into a dummy load", sniffed my friend. "Anyhow, I'm still down in the second or third layer when it comes to DX."

"Too bad", I replied. "Maybe you need a good antenna to make up the difference. Or, maybe its the operator!"

"Phooey," said Pendergast, pushing his test equipment to one side. I'll get back to this later. Have you gotten anything interesting in the mail lately?"

I placed a pile of papers on Pendergast's operating table. "I'm sure you'll be interested in some of this material. For instance, I received a very interesting letter from Ernie, K4RD. He's got two slopers on his tower and has been running some tests on 80 meters (fig. 1). One wire runs 45 degrees north, and the other runs 240 degrees west — almost back-to-back. From W4-land, the first wire is pointed at Europe and the second one at New Zealand. Since the tower is between the wires, Ernie figures that there would be little interaction between them and he could switch back and forth to get some information as to directivity of the wires."

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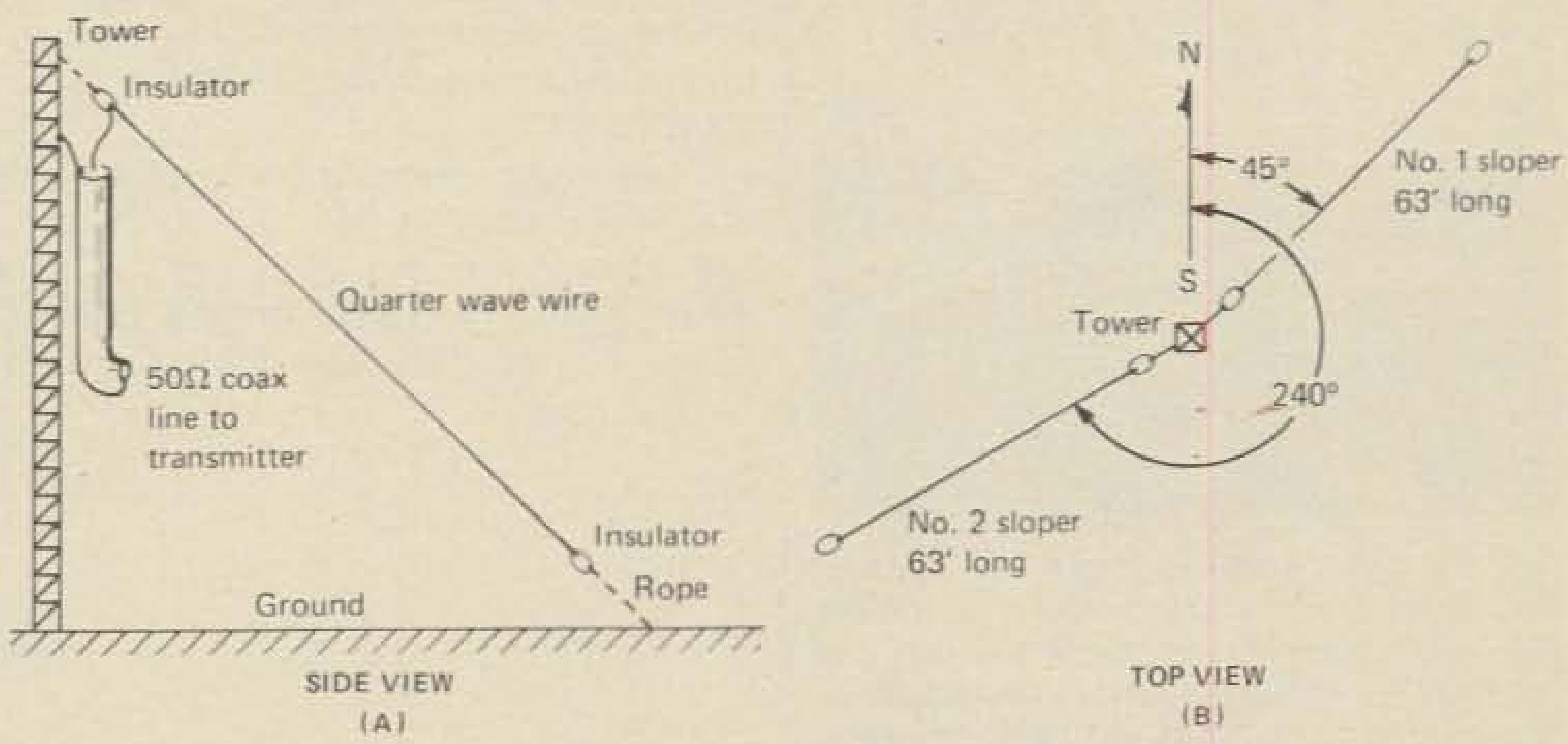

Fig. 1—The sloper antennas of K4RD for 80 meter s.s.b. Number 1 sloper is "aimed" at Europe, Number 2 sloper is "aimed" at New Zealand. The wires are each 63 feet long and make an angle of about 45 degrees with the tower. Each sloper is fed at the top of the tower with a 50 ohm line. The shields of the lines are grounded to the tower. The feed point is about 63 feet above ground.

"How did it work out? Did he find any directivity?", asked my friend.

"Very interesting", I replied. "On tests to New Zealand, antenna number 2 (the 240 degree wire) ran from 10 dB to 20 dB stronger than the number 1 wire. On tests into Europe, however, the number 1 wire was about 10 dB better than the number 2 wire. A test at right angles to both wires (into Central America) showed both antennas to be roughly equal."

"After many tests, switching back and forth between antennas on both transmit and receive, Ernie is convinced that the tower exhibits a shielding effect, which causes a very pronounced null at 180 degrees to the wire. The forward lobe, on the other hand, is very broad".

"How were the wires hung?", asked my friend as he reached for his antenna notebook, preparing to write down the information.

"Both wires were hung from the 63 foot level on the tower. Each wire was 63 feet long, trimmed for 3800 kHz. The included angle to the tower was about 45 degrees.

"Ernie goes on to say the slopers are better than an inverted-V in the same location by an average of one S-unit and the inverted-V is better than a dipole hung in the same place by another S-unit."

Pendergast looked closely at the letter. "What a location!", he exclaimed. "Ernie is about 500 yards from the ocean, and about three feet above sea level. And everybody knows what a good DX location Florida is!"

"Jealousy is a terrible thing", I remarked. "Just look at those less lucky than you. Take Jim, K7DXD. Look at fig. 2. This is a picture of his three-element, triband Quad after a heavy windstorm!"

"He's already got this job down and is going to an expanded Quad (the X-Q design). Each spreader will be sixteen feet long, made up of the usual fiberglass spreader telescoped into an aluminum extension tube."

An eager look crept over Pendergast's face. "Tell me something about the expanded Quad", he asked.

"Well, as you know, Quad-type arrays may be made up having sides a half-wave in length instead of the usual quarter-wave design. A simple beam antenna of this type is the old *Lazy-H* beam, popular in pre-war

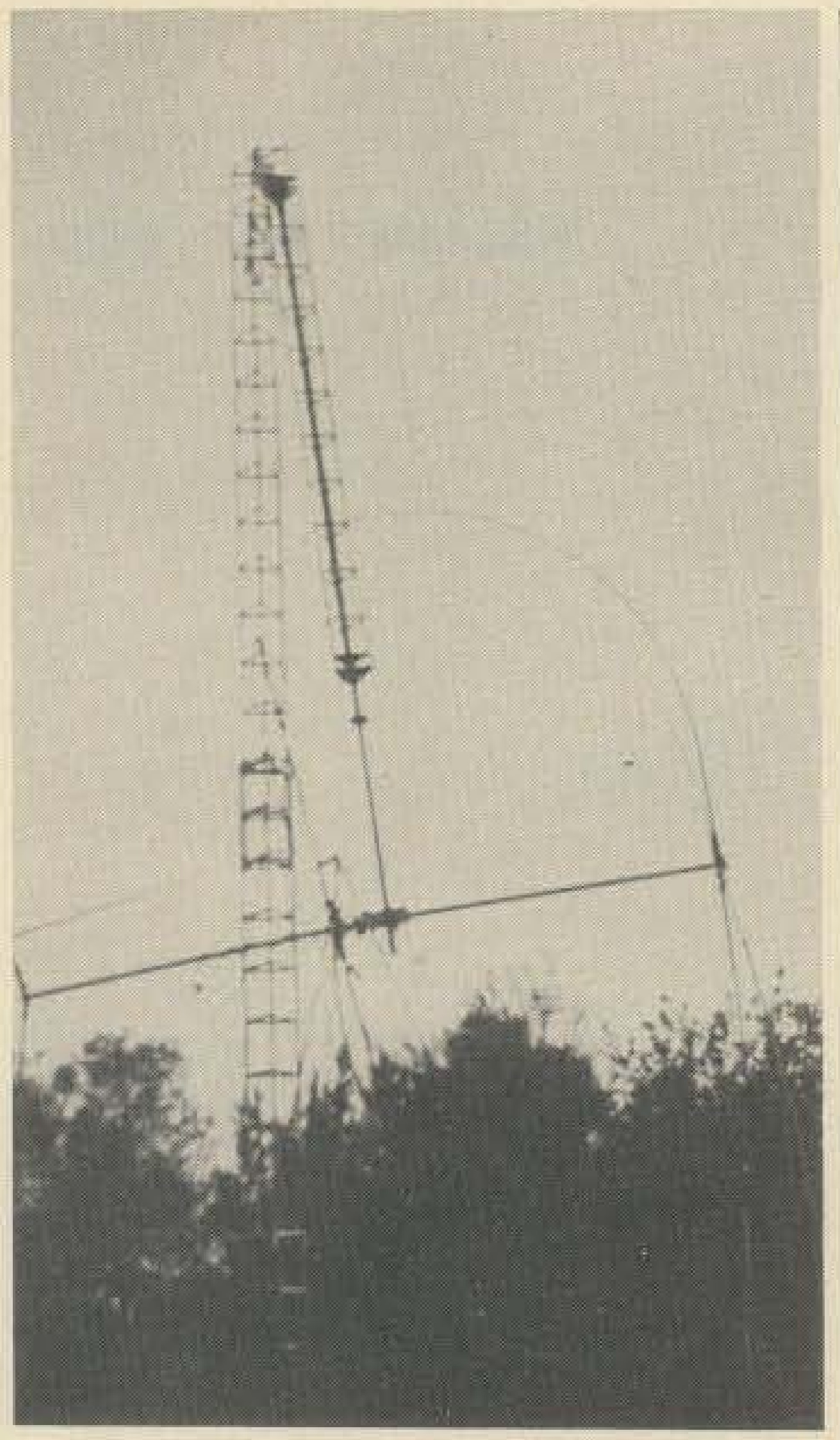

Fig. 2—Never underestimate the force of the wind! Jim (K7DXD) lost his triband (10-15-20 meter) Quad in a windstorm that buckled his crank-up tower. Many towers, while rated to be "guy-less" should nevertheless be guyed at the midpoint and top, especially when a large array is used. Jim's already replacing the tower with a heavy duty job, and is thinking of a 4-element Quad!

years (fig. 3A). The gain of this wire beam is about 5.5 dB over a dipole. The measured gain is the sum of the gain figures for both horizontal and vertical stacking. The *Lazy-H* can be coaxial-fed with a quarter-wave stub and a 4-to-1 balun. The proper phase relationship between the dipoles is achieved through a transposed half-wave phasing line between the upper and lower bays of the array.

"Now, just as with the Quad, the element tips of the Lazy-H can be bent back upon themselves for size reduction as shown in fig. 3B. A high degree of field cancellation takes place around the vertical wires and radiation from these folded sections is considerably reduced. The gain of this enlarged loop antenna is just about 5 decibels. And that's an impresive figure when compared with the gain of the regular Quad loop, which is between 1.5 and 2.0 decibels."

"What about the center phasing line? That looks like a messy affair", grumbled Pendergast, as he copies the sketch into his notebook.

"Well, you can remove the line now, since the upper section of the array is driven by the lower section, and the outer tips are connected together (fig. 3C). The center of the upper section is left open since the two top wires of the array are out of phase with each other at this point. And that's the layout of the X-Q driven loop."

"Can you place parasitic loops in front of, and in back of, the X-Q loop?"

"Certainly," I replied. A two element X-Q array should show a gain of about 9.5 decibels over a dipole, as shown in fig 3D. That's a lot of gain for such a compact antenna."

"How do you feed it?", asked my friend. "I see a quarter-wave stub in these drawings. What's that got to do with it?"

"The low impedance points of maximum current for the X-Q loop are shown in the drawing", I replied. "You can feed at any one of these points. The handiest place to feed the loop, however, is at the center of the bottom section, but this is a high impedance, low current point. It's possible to connect a quarter-wave stub, or transformer, at the center point to provide a convenient, low impedance feed point. The low impedance feed point at the bottom of the stub, or transformer, can be connected to a coaxial line, via a balun. Or, more simply, you can break the loop at one corner and feed it directly, through a balun."

"What about the parasitic element?", asked Pendergast.

"The common design of the X-Q uses a reflector. It is identical in size to the driven element, except that a shorted stub, somewhat longer than a quarter wavelength, is used to tune the parasitic for maximum forward gain. Or, the parasitic element can be tuned as a director, if the stub is somewhat shorter than a

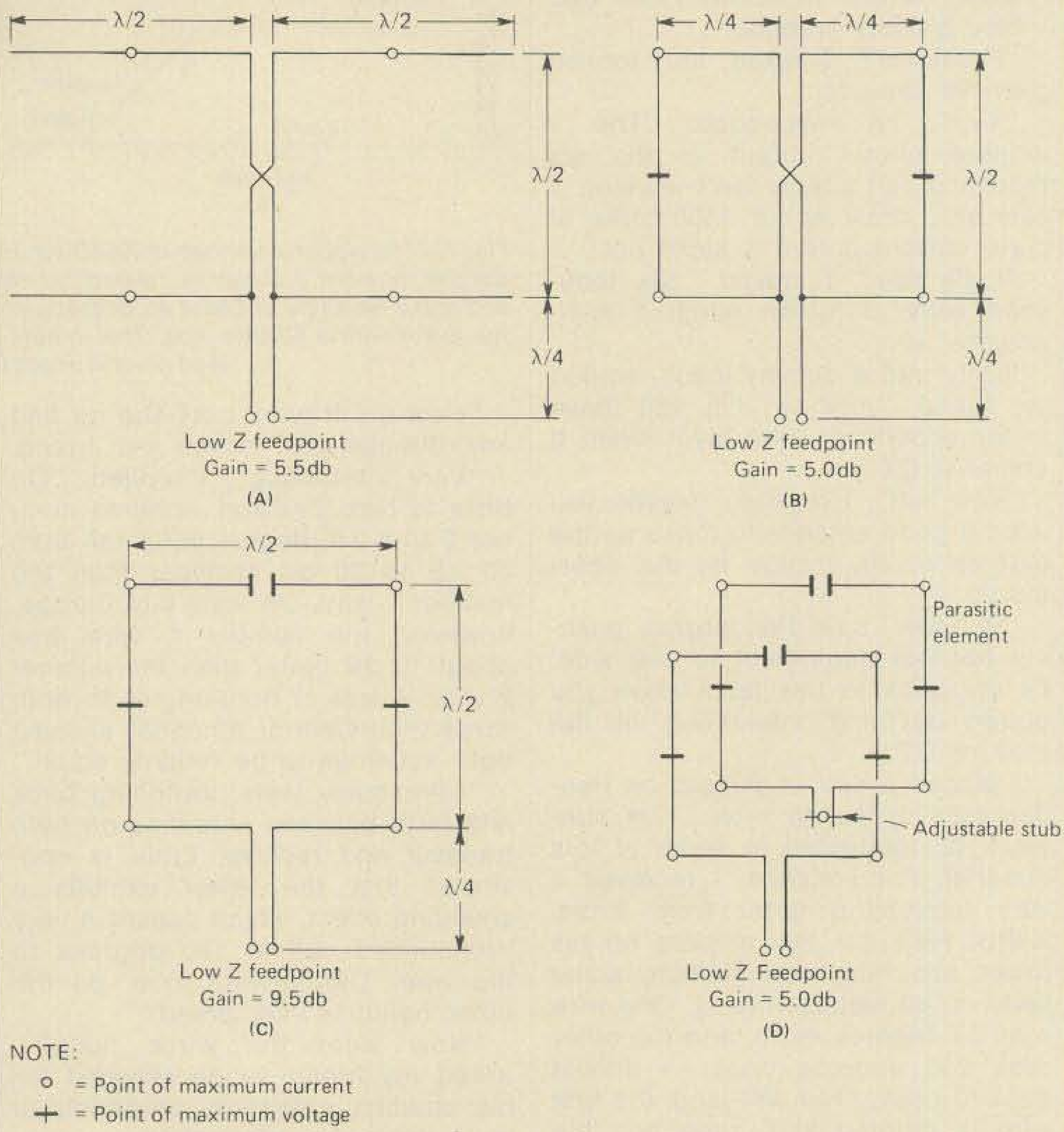

Fig. 3—Evolution of the expanded Quad (X-Q). At (A) is the basic "Lazy-H" beam composed of two half-waves in phase over two half-waves in phase. (B) The ends of the elements are folded back and connected at the points of high voltage. (C) The transposed feedline is removed. (D) A parasitic element is added to form an X-Q beam. Since the bottom of the fed-loop is at a high potential point, a quarter-wave stub is used to transform the feedpoint to a low impedance of about 200 ohms. (Drawing from 'All About Cubical Quad Antennas", Orr. Radio Publications, Inc., Box 149, Wilton, CT 06897. Price $4.75 plus 35 cents postage and handling.)

quarter-wavelength.

"Maximum gain occurs with an element spacing of about 0.125 wavelength. A front-to-back ratio of about 22 decibels is obtainable at this spacing."

"Well", said Pendergast, frowning at his drawings, "It looks to me that a 10 meter X-Q array is easy to build, as its no bigger than a normal 20 meter Quad. And the construction of a 15 meter X-Q is not out of the question. A four element X-Q beam for 10 meters would give nearly 12 decibels power gain, and that's a lot of scrunch!"

"Correct", I agreed. "Now that the 10 meter band is coming back, I think that the X-Q antenna might become a popular beam for that band. I've made up a table of dimensions for a two element array (fig. 4) for those experimentally-minded antenna experts who may wish to try this device."

I reached into a large envelope I was carrying. "I have a couple of items that might interest you", I said. "First of all, here's a sketch of an 'invisible' antenna used by Seth, ON8US in Brussels, Belgium. He lives in an eight story apartment house, but no antennas are permitted on the building."

"So he fed a fishing line down a vent pipe from the roof to his apartment. He tied a weight on the top end of the line. Then he ran a second fishing line from the apartment window to a nearby tree."

"Seth then tied one end of a dipole to the weight on the line that ran down the vent pipe. The other end of the dipole was fixed to the middle of the line running to the tree. He then hauled the dipole up into position as you can observe in fig. 5."

"The foxy idea is that if *point C* of the dipole support wire can slide along the lower line, the dipole can be pulled in against the building when it is not in use. All that is required is that the lower connection permit the dipole to slide along the support line that runs to the tree".

"Very neat", observed Pendergast. "The idea is adaptable to a dipole, or a trap dipole, if you want multiband operation."

"Well, ON8US used transparent nylon fishing line for the supports, so I doubt if you could put much weight into the dipole", I observed.

"I like that", said Pendergast. "That fellow has class!"

"One more idea before we wrap this up", I exclaimed. "Geting back to the many variations of the Quad antenna, I saw a neat design for a

Table of dimensions for X–Q antenna

Band	Side length (L)	Element spacing (S)	Parasitic stub (P) director	Parasitic stub (P) reflector
40	66'8"	17'0"	32'0"	37'6"
20	33'5"	8'6"	15'11"	18'9"
15	22'3"	5'8"	10'7"	12'6"
11 *(Citizens)*	17'5"	4'6"	8'4"	9'9"
10	16'6"	4'3"	7'10"	9'3"
6	9'4"	2'5"	4'5"	5'3"

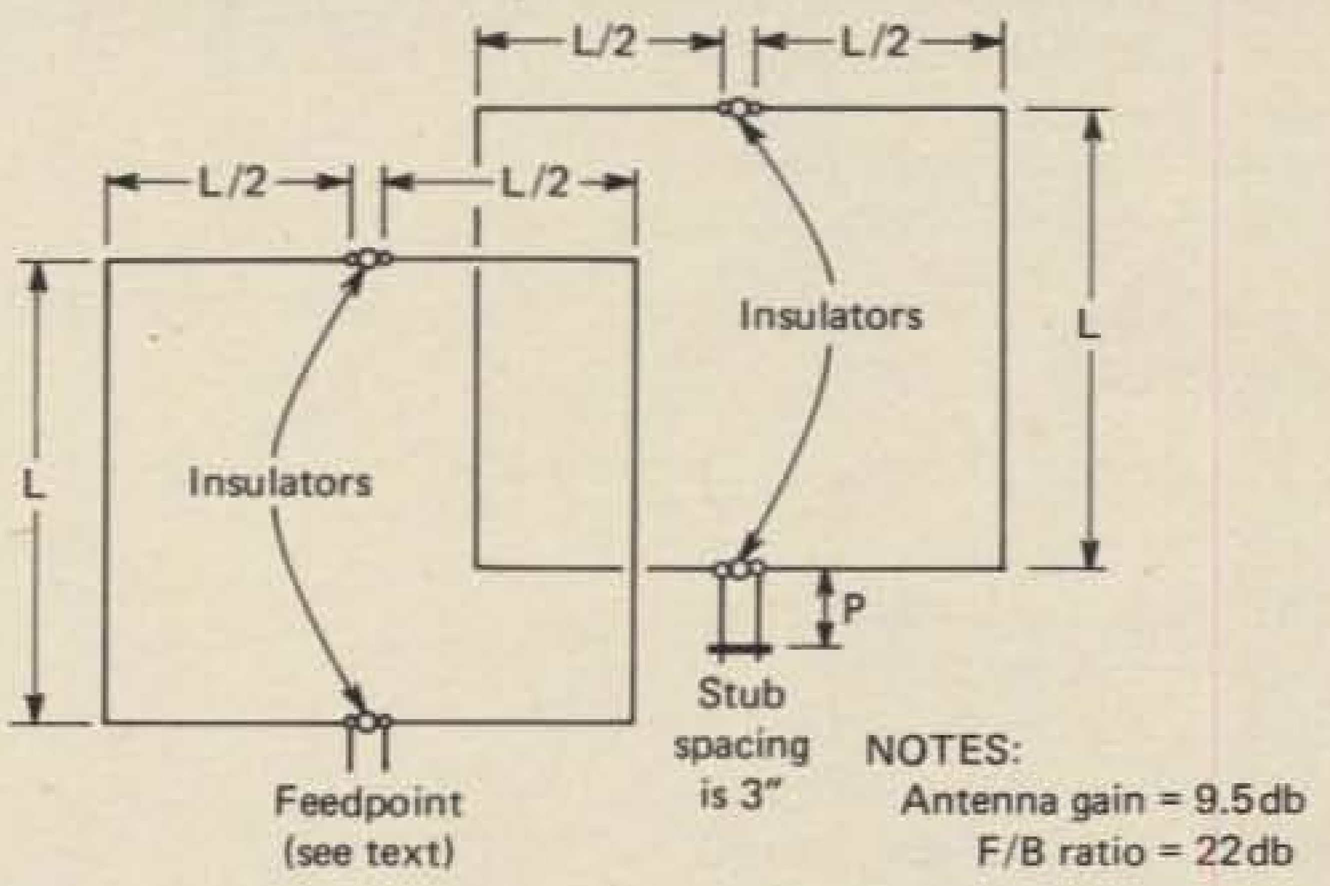

Fig. 4—Chart of dimensions for X-Q beam. Elements are made of wire supported by fiberglass or bamboo arms. A ten meter X-Q beam is about the same physical size as a 20 meter Quad. Antenna may be fed with quarter-wave open wire stub and balun for match to 50 ohm transmission line. (Drawing courtesy of Radio Publications, Inc.)

Quad-type antenna in *Amateur Radio,* the July, 1976 issue. That's the publication of the *Wireless Institute of Australia.* The article was by VK5NO and described a 'double-delta' Quad design (fig. 6). This is a single loop design."

"Two delta loops, each with sides one-half wavelength long, are mounted with their bases parallel and with their apexes at a common point vertically above the center point of the base rectangle. At the common apex point the delta sides from diagonally opposite corners are connected together, thus placing the

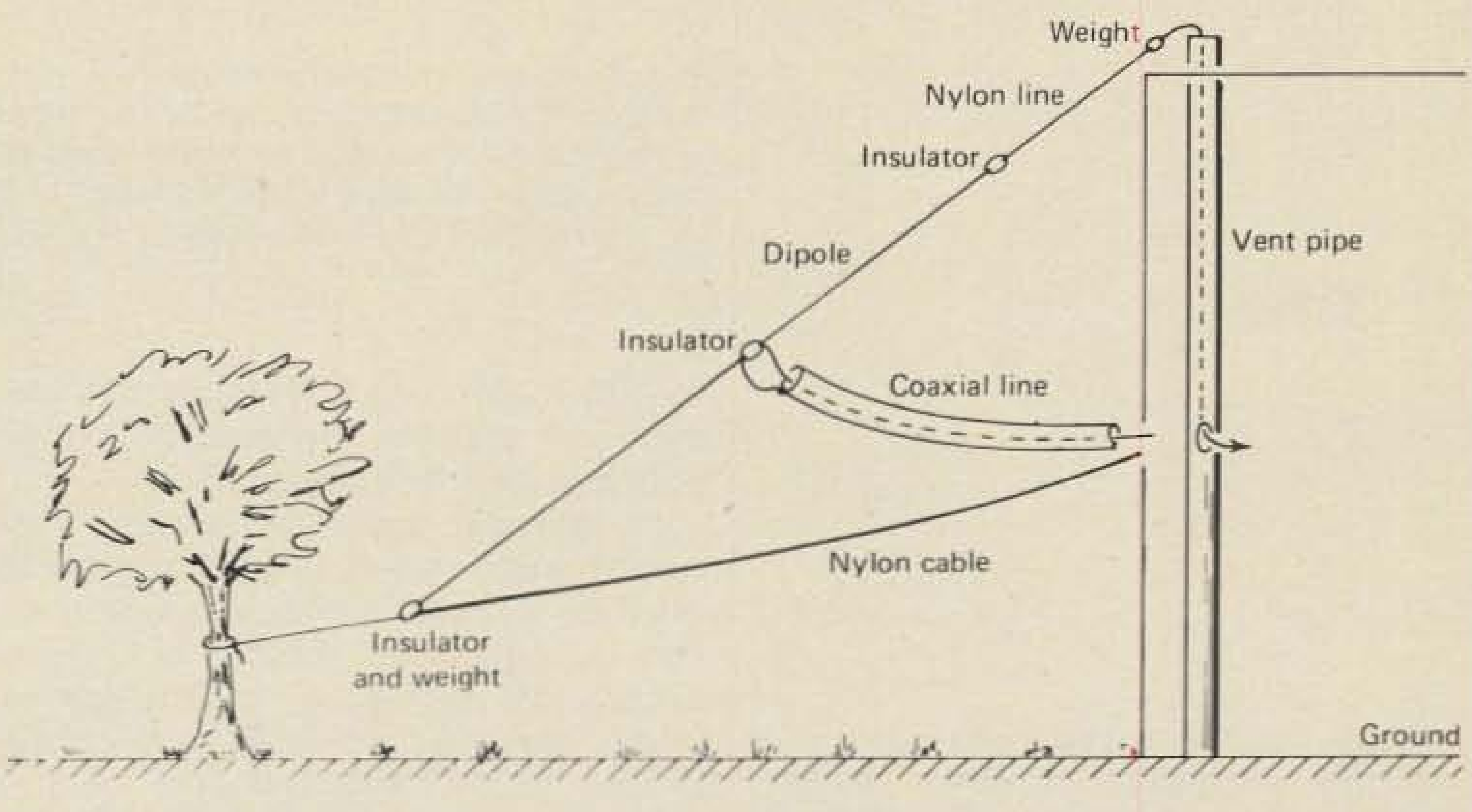

Fig. 5—The "invisible" apartment house antenna of ON8US. The dipole is supported by transparent nylon fishing line and runs between a vent pipe on the apartment roof and a "cable" strung between the apartment and a nearby tree. A nylon line runs down the vent pipe. It is weighted on the top end so that it plays out automatically when the lower end is released. The lower end of the dipole slides along the "cable". By loosening the top end and pulling on the coaxial line, the dipole is brought up against the apartment when not in use.

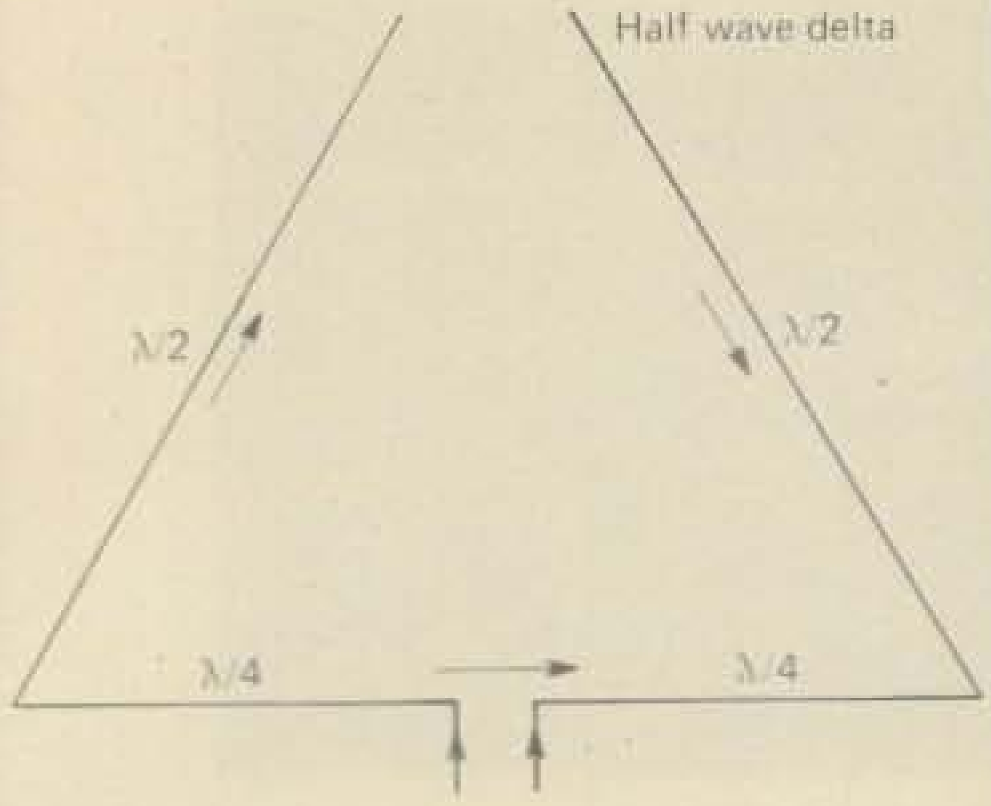

Fig. 6—The half wave delta loop. The feedpoint opposite the apex is low impedance. This large loop exhibits power gain over the more-common delta loop whose sides are about one-third wavelength long. (Fig. 6, 7 and 8 courtesy of the Wireless Institute of Australia).

wires in series connection. The feed point is midway along one of the base sides. The radiation pattern is bidirectional, perpendicular to the base sides, with a figure-8 pattern."

"This is an expanded version of the delta loop (fig. 7). Two expanded loops are connected together so that they are out-of-phase, in the manner of the W8JK beam. The antenna would presumably be more effective if the planes of the deltas were parallel and vertical rather than sloping inward towards the apex, but this would complicate construction.

"Feed impedance is close to 200 ohms, so a 50 ohm line and a 4-to-1 balun are used. To achieve lowest s.w.r., the length of wire is pruned. Ideally, all sides should be pruned equally, but VK5NO pruned only one delta to achieve a low value of s.w.r. and that did the trick, with no apparent effect on antenna performance. The final step was to place 15 meter elements inside the 20 meter elements for two band performance."

"What is the spacing between the loops at the base?", inquired Pendergast, sketching the antenna into his notebook.

"According to VK5NO, the dimension X in the drawing is 12 feet for the 15 meter band and 18 feet for the 20 meter band. Varying this dimension changes the feed point impedance of the antenna".

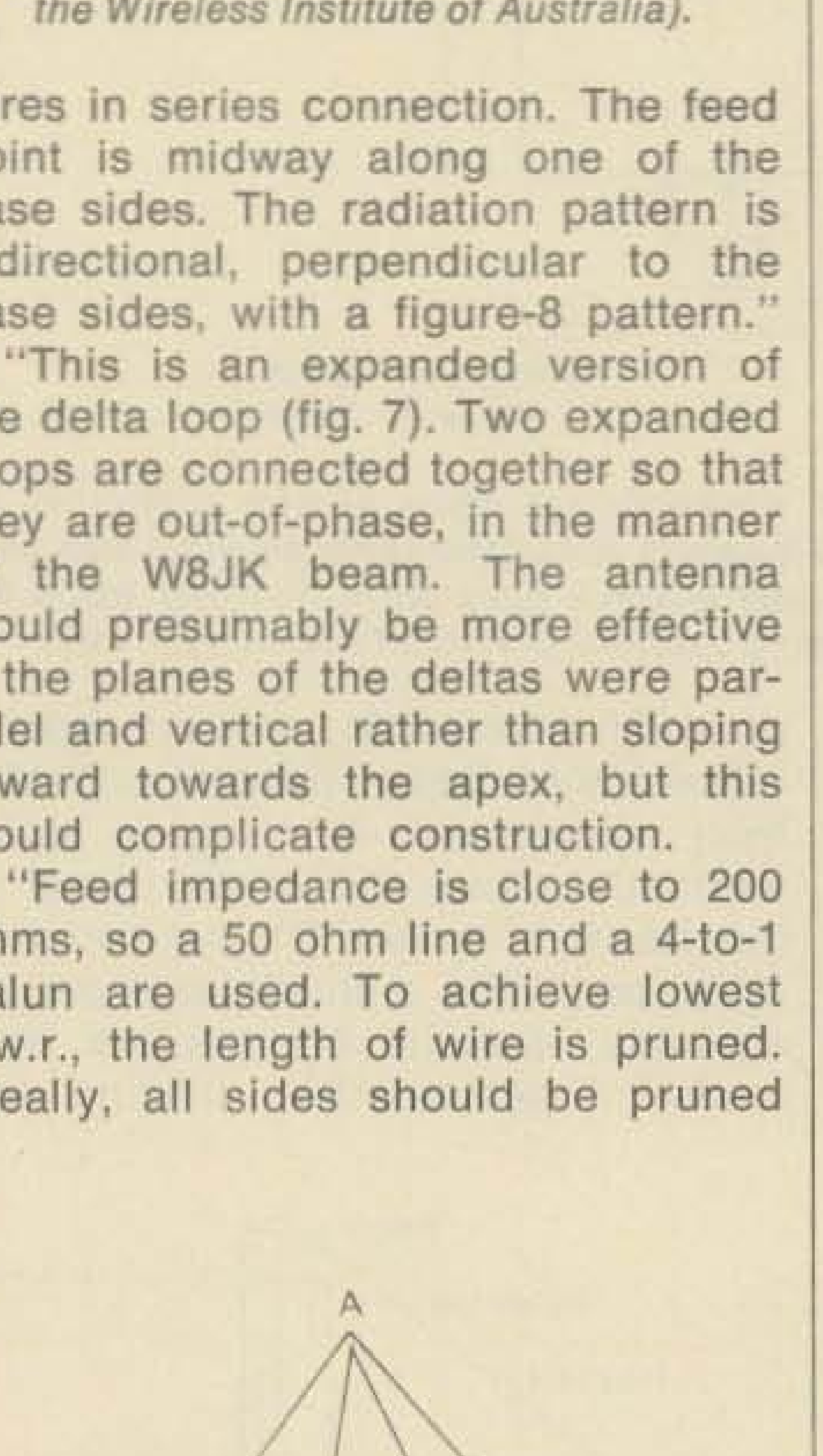

Fig. 7—Two expanded delta loops are mounted with their bases parallel and horizontal and their apexes at a common point vertically above the center point of the base rectangle. At the common apex point the delta sides from diagonally opposite corners are connected together. The feedpoint is at the middle of one of the base sides. The antenna is bidirectional perpendicularly to the base sides.

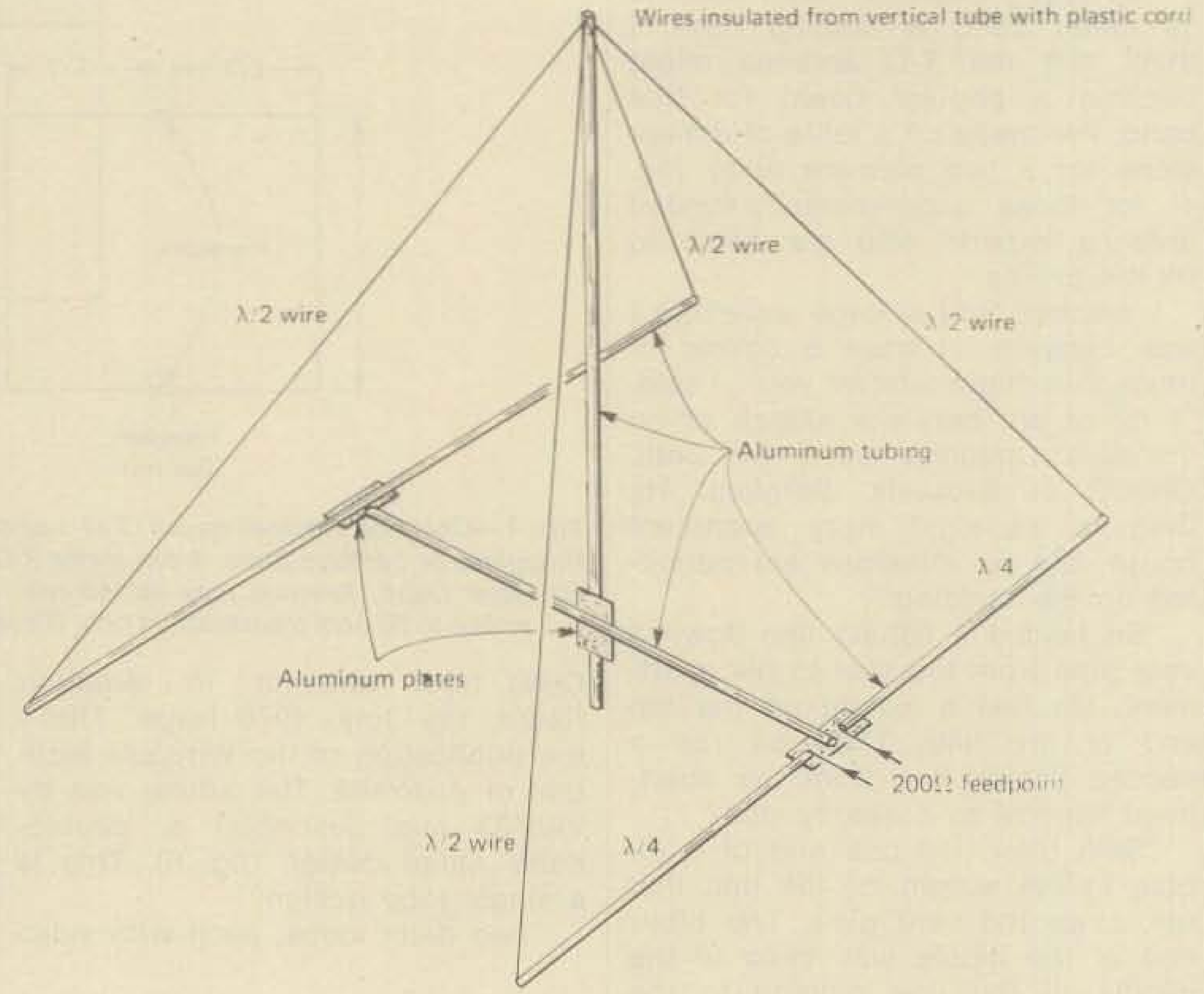

Fig. 8—The mechanical arrangement of the VK5NO expanded Quad. The two base elements are made of aluminum tubing supported by a horizontal boom in the manner of a Yagi beam. A vertical aluminum mast supports the apex, which is insulated from the mast. One of the base tubes is broken at the center for the feedpoint, which is approximately 200 ohms. The beam is fed with a 50 ohm coaxial line and a 4-to-1 balun.

Pendergast said, "I imagine the way to build this is to have a central mast to support the apex, and then run a horizontal boom out, with crossarms on it. The crossarms could serve as the bottom sections of the beam, with the rest of the elements made out of wire" (fig. 8).

"That sounds like the way to do it", I agreed. "Why don't you build one up and see how it works?"

Pendergast sighed. "First of all, I have to get this power supply back together again, or I'll be low man on the DX totem pole. I'll have to use my exciter and intermediate amplifier. And who ever heard of working DX with only 500 watts p.e.p.?"

"Remember, it is ninety percent operator and ten percent station", I replied. "You seem to be rewriting the saying. Well, no matter. The energy shortage will catch up with you sooner or later. And then you'll have to learn to work DX with low power—say maybe a kilowatt or so". ■

a monthly feature by

WILLIAM I. ORR, W6SAI

Antennas

Design, construction, fact, and even some fiction

I have observed from time to time that my friend Pendergast is an unpredictable creature. Today, he looked quite content, his feet up on the operating table, smoking a pipe (unusual for him) as he surveyed his log book and thought about the just-completed DX contest.

"Like a hot knife cutting through butter," he mused. "This is the best score that I've racked up in years."

A new thought struck him. "Too bad the old timers didn't have rotary beams," he remarked. "A good 6-element Long John on a 55-foot boom really works wonders on 20 meters."

"Well, we had beams in the good old days," I replied. "Why should you think that a beam antenna is a modern invention? I'll admit the real old-timers got along without a beam —and did pretty well, too. Look at this photo of the antenna of 9BCV in 1924 (fig. 1). He's WØLFH now. He worked his DX with 10 watts and a cage antenna slung between two poles. The cage was made up of bicycle rims soldered to the wires.

"Now jump ahead to 1936. That's only 12 years later. By then, the rotary beam was in use on the 10 and 20 meter bands. Here's a sketch of a popular design (fig. 2). This little beam was only a quarter-wavelength on a side. The pattern was bidirectional, in and out of the drawing. Actually, the antenna is composed of two half-wavelength wires, bent back upon themselves at the end and voltage fed out-of-phase with a transmission line section. A sort of miniature W8JK beam, if you will.

"The beam was called the *Signal Squirter* and provided about 3 dB gain over a dipole."

"That's not very much gain," observed Pendergast.

"True," I replied. "But it *is* very effective when there are very few beams around. And it provided a simple and inexpensive design whereby the amateur could get his antenna up in the clear. Look at fig. 3. This is a photograph of the Signal Squirter that I erected in 1936. I used it for a year or two, then sold it to a friend who used it for many happy years of DX. It was built around a framework used to support a clothesline. Do you remember the old rotary clotheslines that were in everybody's back yard until the electric clothes dryer came along? Well, the rotary clothes dryer framework, plus bamboo extension arms made up the structure, strengthened with strips of wood at the midpoint of the arms. The antenna wire was strung around the outer tips. A quarter-wave transformer section was used, and the feedline was the famous, old EO-1 twin-wire transmission line."

Pendergast eyed the dim photograph. "That design isn't half bad," he admitted. A gadget built like the antenna in fig. 2 would make a nifty antenna for ten meters—only about 8 feet on a side. And you could feed the quarter-wave transformer section with a coaxial line and a balun."

"That's right," I replied. "It proves there's nothing new under the sun."

My friend placed the sketch in his pocket and glanced over at the pile of mail on the desk.

"What do our buddies out in radioland have to say for themselves?" he asked, as he started to leaf through the letters.

"Look at the interesting letter from Sam, W4BUD. He's got an antenna that is not widely used and has had a lot of luck with it. The original version was called a *Groundpole* antenna which was designed by W6-MUR and was shown in the April, 1959 issue of *QST*.

"The antenna consists of two vertical whips, connected together at the top and spaced about 50 feet apart (fig. 4). One whip is grounded at the base (the high current point) to a set of radial wires. The second whip is fed with a 50 ohm line at the base. Each whip has an adjustable loading coil at the base and the coils are adjusted to provide the lowest value of s.w.r. on the transmission line.

"Sam says he can tune the antenna up on both 40 and 80 meters by adjusting the coils. He says it works as well, or better, than a trap dipole at the same height and is small enough to fit into his back yard."

Pendergast eyed the drawing thoughtfully, then he said, "It seems to me that the point of maximum current can be varied in position along the wire by adjusting the variable inductors. I remember an old *QST* article by John Reinartz, W1QP, where he showed an antenna which had a variable angle of radiation. He moved the current points up and down a vertical wire and out along a horizontal wire to achieve the

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Fig. 1—Old timers worked DX with a simple cage antenna. This is the cage of 9BCV (now WØLFH). In 1924 9BCH had a 10 watt, loop modulated phone transmitter. He tried to work Chicago with it and never did . . . which was pretty good DX for those days.

angle of radiation he wanted."

"I remember that, too," I admitted. "It must have been about 1936. Well, it would be interesting to play with an antenna of this type and see if it is possible to vary the angle of radiation by moving the maximum current from the vertical whips into the horizontal wire. Maybe Sam will try this experiment and let us know."

Pendergast held up a magazine that he had pulled out of the pile of mail. "Here's an article about another interesting combination of horizontal and vertical polarization. It's in the January, 1977 issue of *Radio Communication*, that great magazine of the Radio Society of Great Britain. It describes the antenna of F0AXP who wrote it up in the German magazine *QRV*. . ."

"From *QRV* to *Radio Communication* to *CQ*, eh?" Pendergast interrupted himself. "It sounds as if there's a lot of incest in the antenna game."

I ignored his thrust and said, "The antenna seems to be a 'half-Quad.' It is 'upside-down' as far as the W4-BUD antenna is concerned. That is, the ends of the wire closest to the ground have maximum voltage and maximum voltage at the middle of the horizontal wire (fig. 5). The antenna is end-fed with a quarter-wave transformer from a coaxial line. The points of maximum current fall at the tops of the vertical sections."

"What kind of radiation pattern does it have? Is it horizontally or vertically polarized," asked Pendergast as he sketched the antenna in his laboratory notebook.

"Beats me," I replied. "You have high current in both the horizontal and vertical sections. Why don't you build one up and find out instead of asking me?"

Pendergast gestured at the magazine, laying open on the desk. "This whole family of inverted antennas really derives from the long-forgotten *Chireix-Mesny* antenna, named after the two French radio engineers who designed beam antennas in the early *twenties* (fig. 6). In this beam antenna, the half-wave dipole elements are arranged in the form of sawteeth, rather like an array of large Quad elements. Each dipole element is driven directly by the one preceding it. This array is large for the high frequency amateur bands, but might well be worth investigating for v.h.f. work. From the point of view of the radiated field, this arrangement is equivalent to an array of parallel dipoles."

"That's right," I replied. "Look at fig. 7. This is one element of the

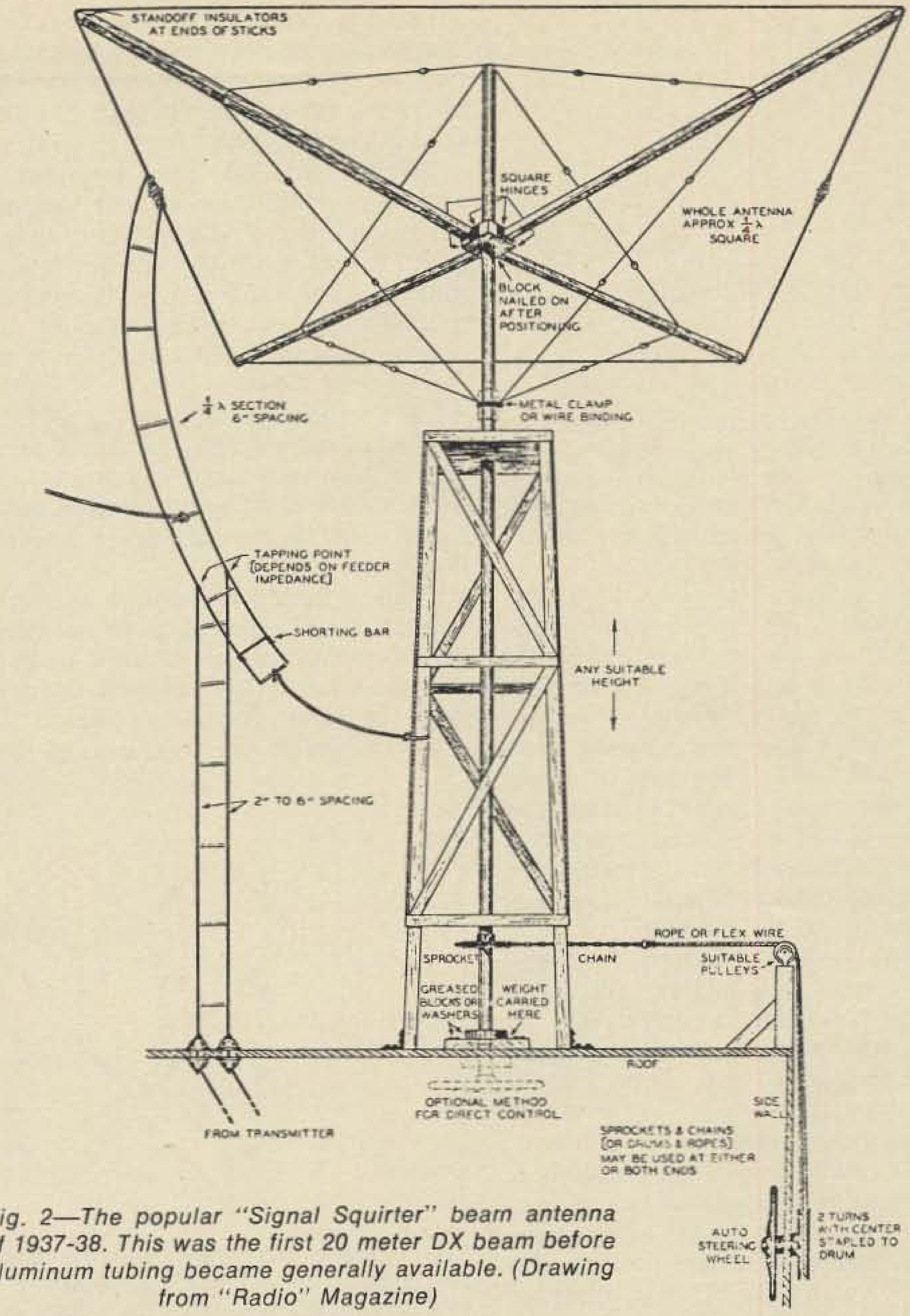

Fig. 2—The popular "Signal Squirter" beam antenna of 1937-38. This was the first 20 meter DX beam before aluminum tubing became generally available. (Drawing from "Radio" Magazine)

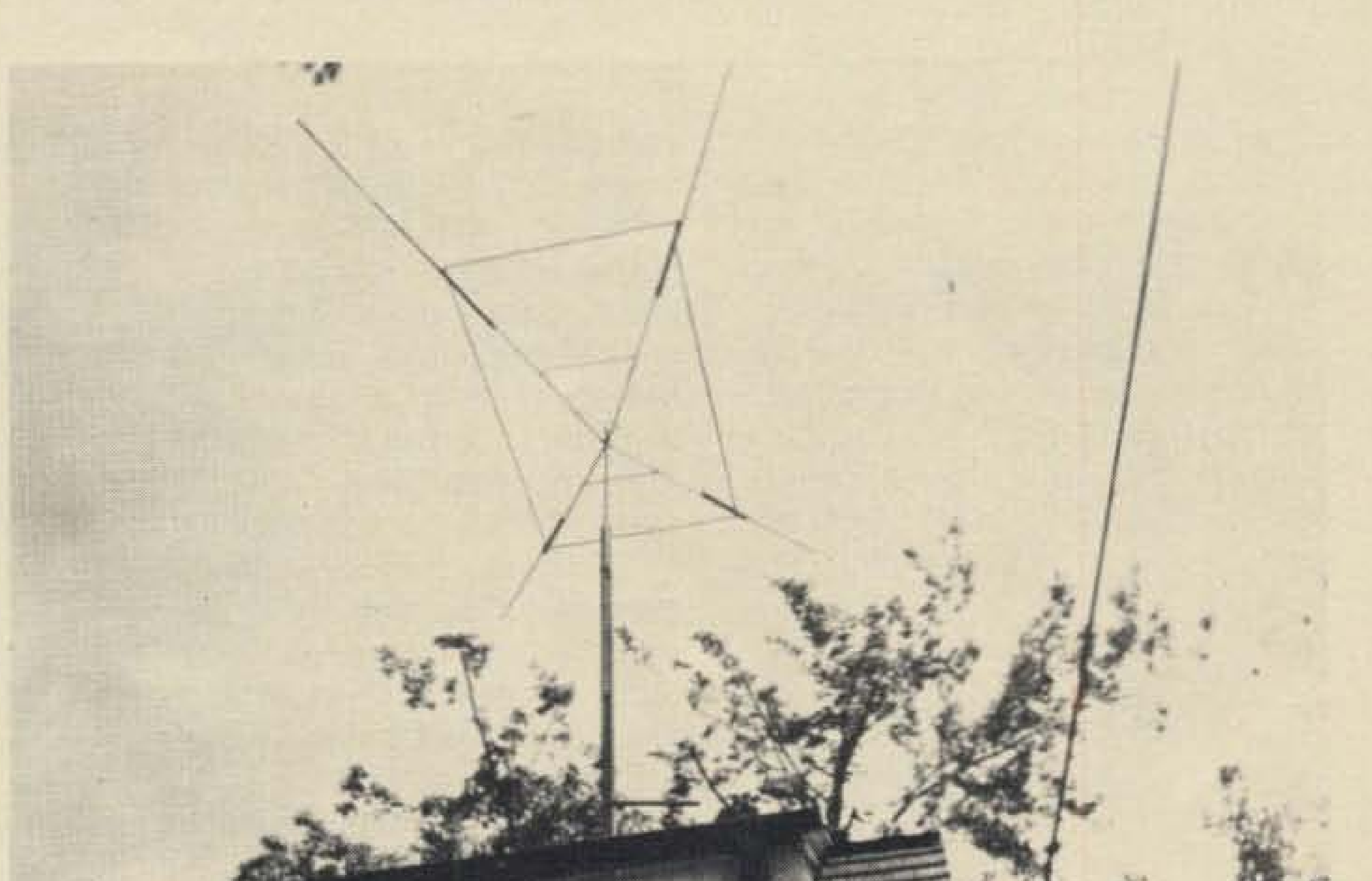

Fig. 3—The "Signal Squirter" beam at W2HCE in 1936. The bidirectional beam provided 3 or 4 dB gain which was enough to make the signal head and shoulders above most of the other DXers on the band! Sold to W2DQT in 1938, the beam provided many more years of good DX until it was destroyed in a hurricane shortly after World War II.

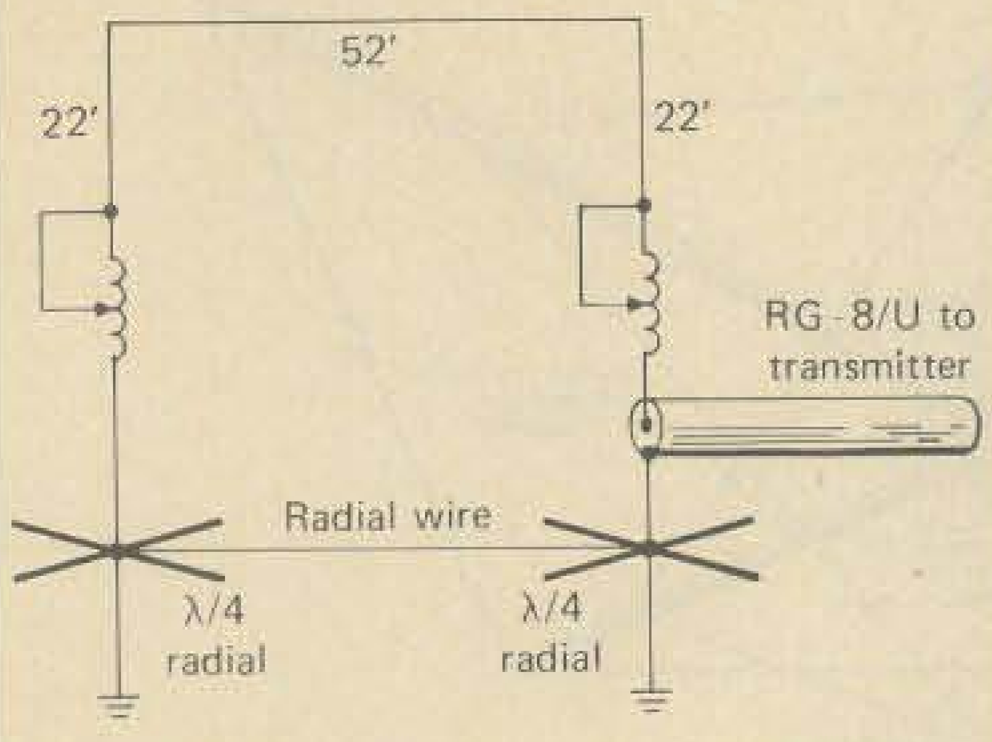

Fig. 4—The twin Groundpole antenna of W4BUD. Two whips connected together at the top provide a loop antenna with one side at ground level. Adjustable loading coils provide plenty of room for experimentation.

Chireix-Mesny array. Do you recognize it? It is an end-fed inverted-V antenna. This is a single band, vertically polarized antenna. The stub can be fed in any conventional manner. Ted, ZS6BT, uses two of these simple antennas, one on 14 MHz and the other (with a V-shaped reflector spaced 0.1 wavelength behind it) on 28 MHz. He reports that the inverted-V design is roughly equivalent to a half-wave vertical antenna, but appears to be less noisy and less prone to fading on reception. On 10 meters, he has a vertically-polarized broadside beam, supported by a single mast."

"Interesting," remarked my friend. "*Radio Communication* is certainly a fine magazine. I enjoy it!"

"One more item in the same publication. G3LHZ has been doing a lot of work with the Quad antenna, along with G8IBQ. They have developed an interesting variation of the Quad loop. Look at fig. 8, which illustrates three versions of the center-fed loop antenna. The first type (a) is familiar to vhf operators as the so-called "skeleton slot" antenna. Type (c) is a three-wire folded dipole. And in between these two extremes is the square loop configuration of illustration (b).

"Because this antenna is square, it can be driven symmetrically, that is, from the opposite points. This

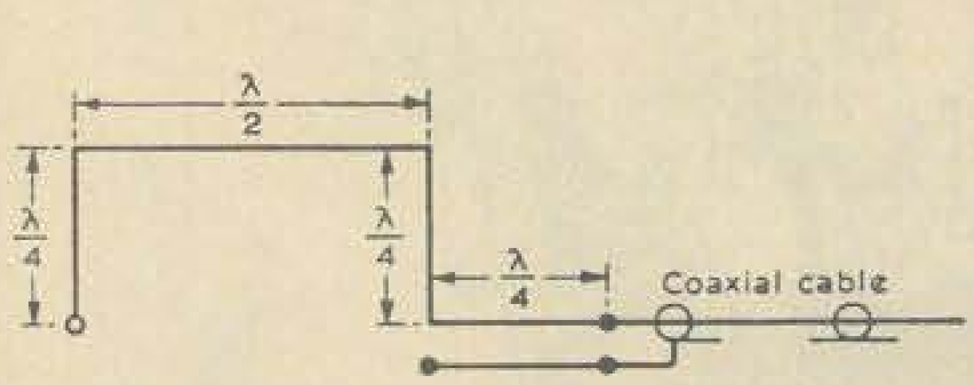

Fig. 5—The half-loop antenna of F0AXP. The wire is one wavelength long, voltage fed at one end with a quarter-wave stub and coaxial line. (Drawing from "Radio Communication")

solves the problem of different polarization that is required on 144 MHz. That is, vertical polarization for f.m. and horizontal for s.s.b. And circular polarization for the Oscar Satellite.

"Well, because the antenna is square, no voltage should appear across points A-A¹ when power is applied to points X-X¹ (fig. 9). And it follows that when power is applied across Y-Y¹, no voltage should appear across the equivalent points on the vertical sides.

"A test loop was built by G3LHZ and, after adjusting it for exact symmetry, the idea was confirmed, as an isolation of 30 to 40 dB was measured over a bandwidth of several percent.

"The radiation resistance of either pair of inputs was found to be close to 300 ohms, so a 75 ohm coaxial line and balun (fig. 10) was used to feed the loop. The balun length (L) is a half-wavelength, allowing for the velocity factor of the cable, which is about 0.67 for the ordinary types.

"Next, G3LHZ built up a 10-element Quad based upon this design. It was built of #14 wire loops suspended on a bamboo pole. The reflector and directors were conventional 2-meter Quad elements. The reflector was 22 inches on a side and spaced 15 inches from the new Quad, which was the driven element. The first director had 19.5 inch sides, the second director 19 inch sides, the third to eighth directors 18.5 inch sides, with all directors spaced at 15 inch intervals from the driven element. The overall boom length was about 11 feet, three inches.

"The s.w.r. was about 1.2-to-1 at the center of the 144 MHz band when a 50 ohm transmission line was used, the parasitic elements tending to lower the radiation resistance of the Quad loop. It was found that the antenna input was slightly reactive and a small variable capacitor of about 4 pF was necessary across one set of terminals. This may have been due to the construction of the array, as the capacitor was needed on one set of terminals only.

"Once the antenna was matched up, it was compared against an 8-element Yagi which had a gain of 9.5 dB. The new Quad design proved to be better by 4 to 5 dB using both a calibrated signal generator and reception of 144 MHz beacon signals."

"This sounds like a great v.h.f. antenna," remarked Pendergast, as he made a graceful drawing of the antenna array in his notebook. "I wonder why more v.h.f. amateurs don't use the Quad antenna?"

"More and more are using it," I replied. "One moon-bounce enthusiast, K6YNB, has an array of sixteen, 3-element Quads that is a real block-buster."

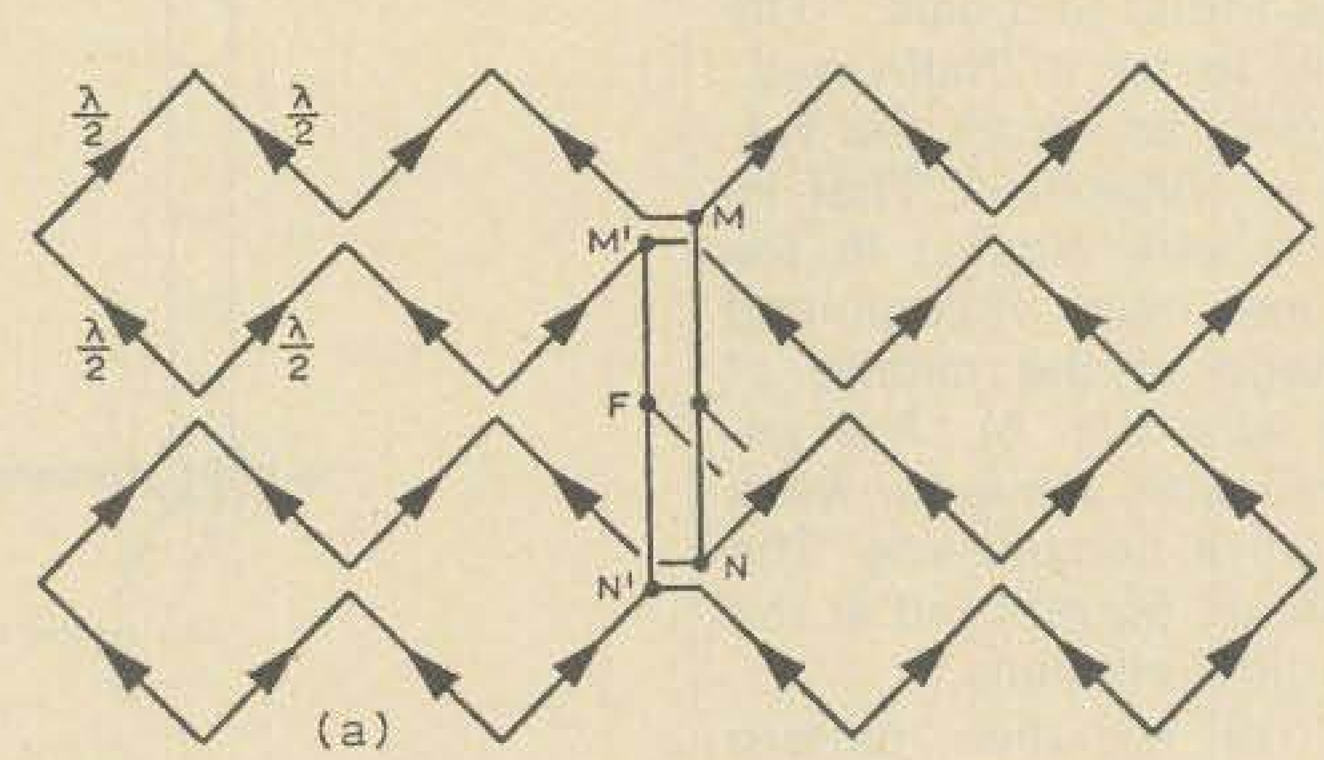

Fig. 6—The Chireix-Mesny beam antenna is made of dipoles arranged in the form of diamonds. Each leg is a half-wavelength long. The array is fed at the center with a short double-ended stub. The pattern is vertically polarized, in and out of the page. (Drawing from "Radio Communication")

"How does G3LHZ switch polarization?" asked Pendergast.

"He has a relay placed at the antenna," I replied. "But he's going to try circular polarization next, feeding each input with equal power, with a phase shift of 90 degrees between the inputs. This can be easily obtained with a quarter-wavelength section of feedline. Each set of inputs to the Quad loop would then

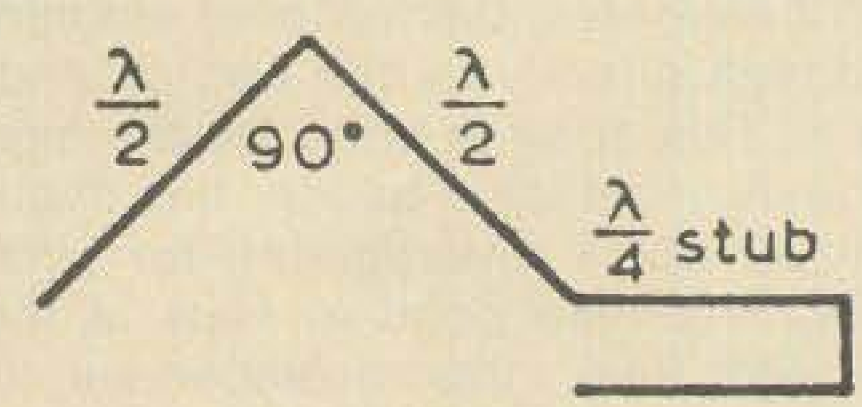

Fig. 7—The simple antenna of Ted, ZS6-BT. (Drawing from "Radio Communication")

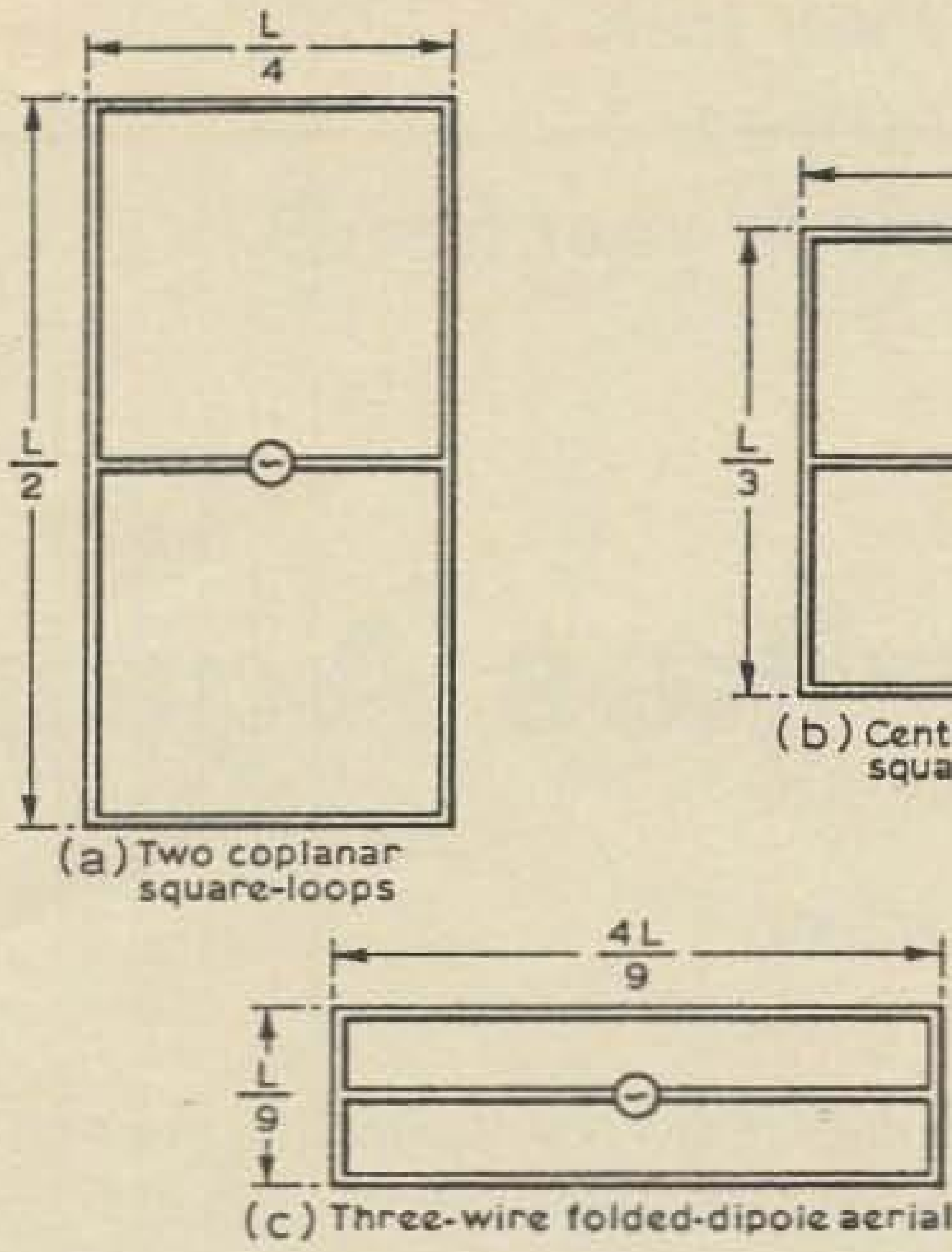

Fig. 8—Three variations of the Quad loop. At (a) is the so-called "skeleton slot" v.h.f. antenna composed of two "Quad" loops having a common feed point. At (b) is a square loop, one-third wavelength on a side. At (c) is a three wire folded dipole. All are "cousins under the skin."

have to be adjusted for exactly 50 ohms. G3LHZ found that he could increase the radiation resistance at the feedpoints by up to 25 percent by making the driven loop about 12 percent larger on a side. And he could tune either input to a chosen resonant frequency by placing a small shunt capacitor across the input terminals. So the design is very flexible as far as adjustment goes. It would appear that this unusual driven element could be substituted for the conventional driven element in a v.h.f. Quad with little trouble.

"You must remember, however, that in any Quad design—h.f. or v.h.f.—while the driven Quad loop is relatively broadband, the parasitic element loops are by comparison much more narrowband. Because of this, antenna gain and front-to-back ratio are only maintained over the relatively narrow band over which the parasitic elements operate correctly. And this restriction holds true for the Yagi antenna, too."

"Well, darn it," said Pendergast, shifting in his chair, "I like to work c.w. at 144.0 MHz, s.s.b. at 145.1 MHz and also f.m. at the top of the band. How do I cover the whole 2 meter band with a beam and get good power gain and good front-to-back ratio across the whole band?"

"It isn't easy," I admitted. "One of the best antenna designs that actually accomplishes this is the so-called LPY (log periodic Yagi) design. The LPY beam will provide good gain, good front-to-back and low s.w.r. across the whole 2 meter band. I hope to discuss this unusual antenna in a forthcoming column."

"You do that!" retorted my friend. "Now that amateurs are spreading out across the 2 meter band, there's activity from one end to the next. And a good, wideband beam antenna is a great comfort when you zip from one end of the band to the other!"

* * *

Note: Information about *Radio Communication* magazine may be obtained from the Radio Society of Great Britain, 35 Doughty St., London, WC1N-2AE. Additional information on the K6YNB multi-Quad, 144 MHz beam can be obtained by writing: Amateur Service Department, EIMAC division of Varian, 301 Industrial Way, San Carlos, CA 94070. Ask for Amateur Service Bulletin 49-15. ■

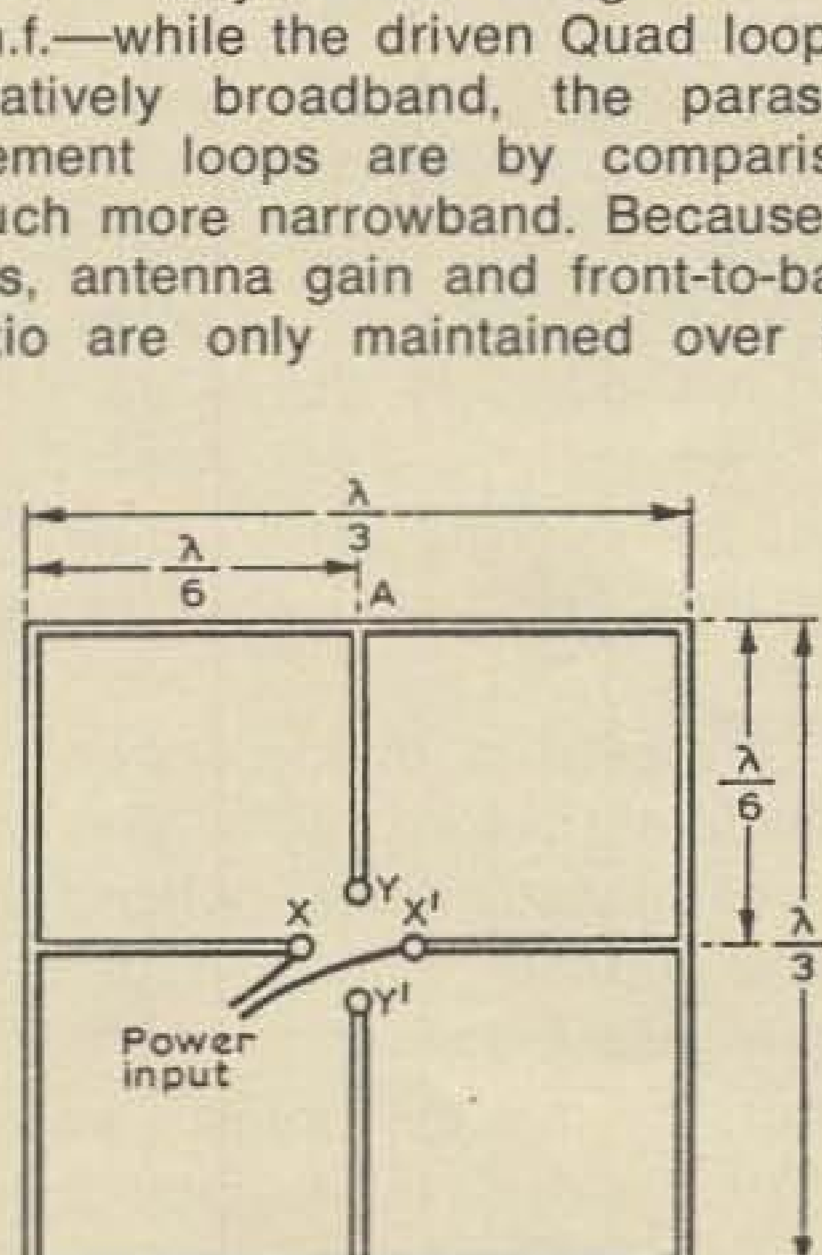

Fig. 9—The "one-third wavelength loop" arranged for either vertical or horizontal polarization.

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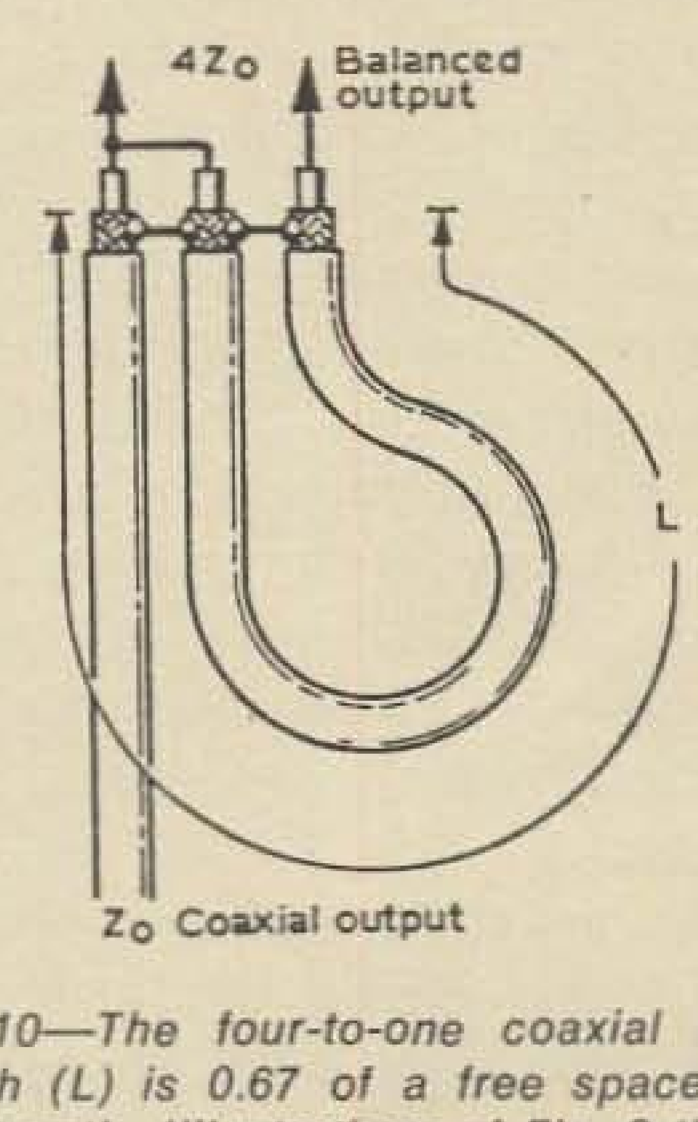

Fig. 10—The four-to-one coaxial balun. Length (L) is 0.67 of a free space half-wavelength. (Illustrations of Fig. 8 thru 10 are from "Radio Communications").

a monthly feature by

WILLIAM I. ORR, W6SAI

Antennas

Design, construction, fact, and even some fiction

I thought Pendergast was going to bust a gut laughing. He dropped the paper he was reading and curled up on the sofa, howling with glee.

"What's so funny?" I asked, as I dropped a pile of mail on the desk.

He picked up the paper and showed it to me. "Well," he replied, "Somebody mailed me a description of your *CQ* antenna column. Want to hear it?"

"Sure," I replied. "Go ahead."

Pendergast composed himself and read solemnly from the letter.

"W6SAI is an exacting expert on the basis of being able to turn out, after innumerable de-bugging sessions, an infinite series of incomprehensive antennas calculated with micrometric precision from vague assumptions based upon debatable figures taken from inconclusive experiments of problematical accuracy by persons of dubious mentality for the purpose of confounding a defenseless group of amateurs unfortunate enough to have asked for the information in the first place."

"Well, that seems to cover the subject pretty thoroughly," I replied. "I'll just pack my bag and leave quietly."

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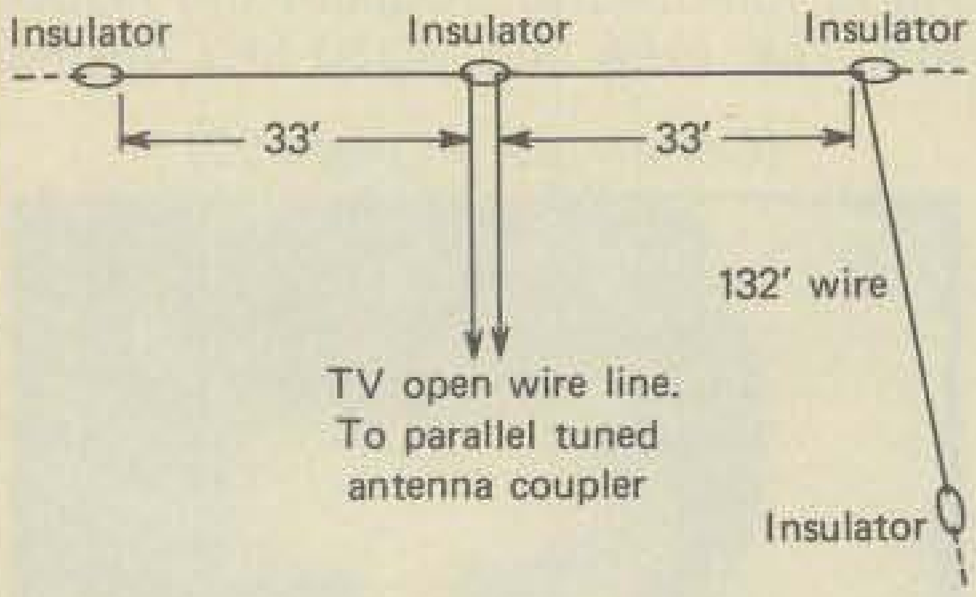


Fig. 1—The ZL2AKW multiband antenna. A 66 foot center-fed antenna works on 40, 20 and 15 meters. For 80 and 160 meters, a 132 foot wire is attached permanently to one end of the dipole and brought off at right angles to the dipole. On 160 meters, the feeders are tied together and the antenna is operated as a Marconi against ground. The transmission line should be between 35 and 45 feet long.

"No, no!" said my friend. "Let's look at the mail instead and try and find another gem like this one."

"Alright," I replied. "Here's the first letter and it is from ZL2AKW, down under in New Zealand. Trevor describes a multiband antenna that has worked well for him (fig. 1). Basically, it is a center-fed antenna, sixty-six feet long. The feeder is TV-style open wire line and he uses a parallel-tuned antenna coupler at the station. The feedline, by the way should be 35 to 45 feet long for best results on 80 meters.

"This antenna acts as a center-fed dipole on 40 meters, two half-waves in phase on 20 meters and as a center-fed long wire on 15 and 10 meters.

"Now, for 80 and 160 meters, Trevor has attached a 132 foot wire to one end of the center-fed antenna. This runs at right angles to the smaller antenna and provides low-band operation. On 160 meters, the feeders are tied together and the antenna is worked against ground as a Marconi. He says the addition of the long wire doesn't seem to upset the balance or the operation of the center-fed antenna on the higher bands. And he also says the long wire is very thin and almost invisible, which is very helpful if it happens to run across somebody else's property!"

"Very good," exclaimed Pendergast. "I'll write this one up in my notebook. "And it looks as if you have another letter from "down under," judging from the stamp."

"No, it's from Canada," I replied. "From Glenn, VE3CGU, to be precise. He reminds me of an antenna that I've never discussed in *CQ*, namely, the loaded dipole. However, I did write something about this interesting antenna in the June, 1975 Antenna Column. However, Glenn's antenna is something like the K1PLP design shown in September, 1974 *QST*. That article is a "must" for anybody interested in compact dipole antennas for the low bands. Anyway, Glenn's antenna is shown in fig. 2. Basically, it is a 40 meter dipole with loading coils and end extensions to make it resonate on 80 meters as well. This is a slightly different design than the one shown in *QST*. The *QST* design is a good one, but it is single band. This arrangement works on several bands. On 40 meters the loading coils act as r-f chokes and effectively decouple the tip sections. On 80 meters, the coils act as true loading coils. And the 40 meter portion works well on the third harmonic, which is 15 meters."

"Seems to me I remember an antenna of this type described by W4-JRW some years ago," remarked Pendergast.

"That's right," I replied. "This design is very effective as it works on three Novice bands. The only critical sections of the antenna are the tip lengths. The operator should run a SWR curve on 80 meters and then trim the tip sections for lowest SWR at a chosen frequency, as the bandwidth of the antenna on 80 meters is only about 50 kHz. Of course, bandwidth is very good on 40 and 15 meters, the whole band is covered in each instance with no sweat."

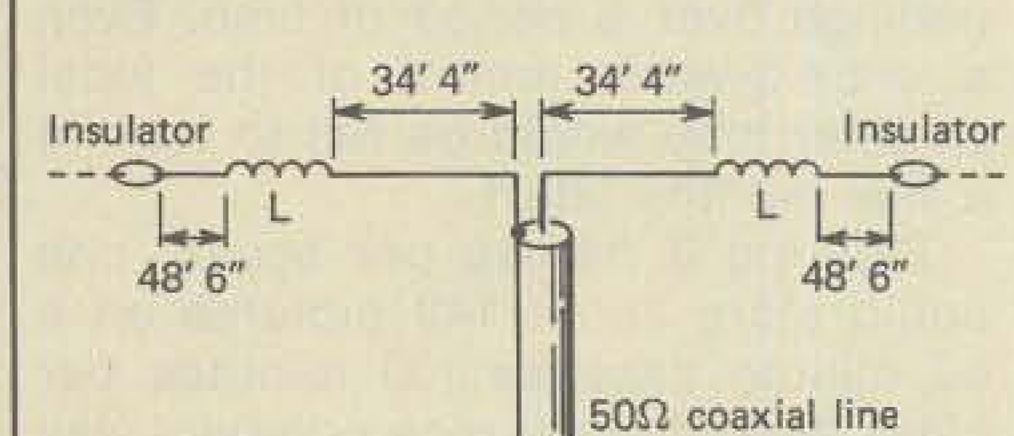


Fig. 2—The VE3CGU Novice antenna for 80, 40 and 15 meters. The center section of the antenna works on 40 and 15 meters while the coils (L) act as r-f chokes, isolating the end sections. On 80 meters, the coils act as loading coils so that the overall antenna is resonant in the 80 meter band. Each coil consists of about 50 feet of #18 enamel coated wire close-wound on a piece of PVC plastic pipe, 1¼ inches in diameter. Tip lengths are adjusted about ½ inch at a time (equally) to bring resonant frequency to chosen spot in the 80 meter band. Bandwidth at 80 meters is about 50 kHz.

Pendergast peered over my shoulder at VE3CGU's letter. "Glenn says the coils are made up of 50 feet of #18 enamel wire closewound on a 1¼ inch (outside diameter) piece of PVC plastic pipe. He feeds the dipole directly with 50 ohm coaxial line: RG-58/U to be exact."

"It's a good antenna," I said. "You can work three bands and you don't have to fiddle with traps, which can get to be pretty tricky."

Pendergast thought a moment, then said, "You know, there's another good antenna that has just about disappeared from the world of amateur radio. And its a pity, because it is a good antenna. Too bad more fellows don't use it."

I guessed what he was driving at. "You mean the single-wire fed antenna?"

"That's right," he replied. "I've used one for years, as you know, and it really *works!*"

"The single-wire fed antenna was first described by Everitt and Byrne in the October, 1929 issue of *Proceedings of the IRE.* The work was done at Ohio State University, which seems to have more than its share of antenna experts," I remarked.

"A modern version of the single-wire fed antenna is shown in fig. 3. This employs a simple L-network to match the approximate feeder impedance of 700 ohms to a 50 ohm termination. Since the antenna feed impedance is so high, ground losses are quite low and the antenna is much more efficient than a Marconi antenna when it comes to ground losses."

Pendergast asked, "How do you keep the single-wire feeder from radiating?"

"That's an interesting point," I replied. "In the 1929 article feeder radiation was discussed extensively and the conclusion was reached that if the feeder was properly terminated at the antenna, there would be no radiation from the feeder."

"Wait a minute!" exclaimed my friend. "How can a single wire, carrying r-f current, not radiate? That's impossible!"

I reached up on the shelf and brought down the 1929 issue of the *Proceedings.* It was a thin, gray volume, about half the size of the present *I.E.E.E.* magazine.

"Let me read to you from the article," I said. "I'll omit the double quotation marks, which are messy and confusing."

"When a single electron is moving at a constant velocity, no radiation occurs. If the electron is accelerated or decelerated, radiation will take place. However, the radiation is due, not to the acceleration or deceleration of the electron itself, but to the acceleration of a portion of the field, although it is realized that the two cannot be separated in the case of the single charge.

"Similarly if a series of doublets along a transmission line are so arranged in phase that the field is propagated along the line with a constant velocity, no radiation will take place. This constant velocity occurs when there is a continuous shift in phase of the doublets, so that even though the electrons flow first in one direction and then the other, the resultant field moves with constant speed. This condition is produced on a transmission line when there is no reflection and therefore no returning wave.

"By application of the reciprocity theorem and a study of wave antennas it will be concluded that there will be a small radiation in the direction of the transmission line.

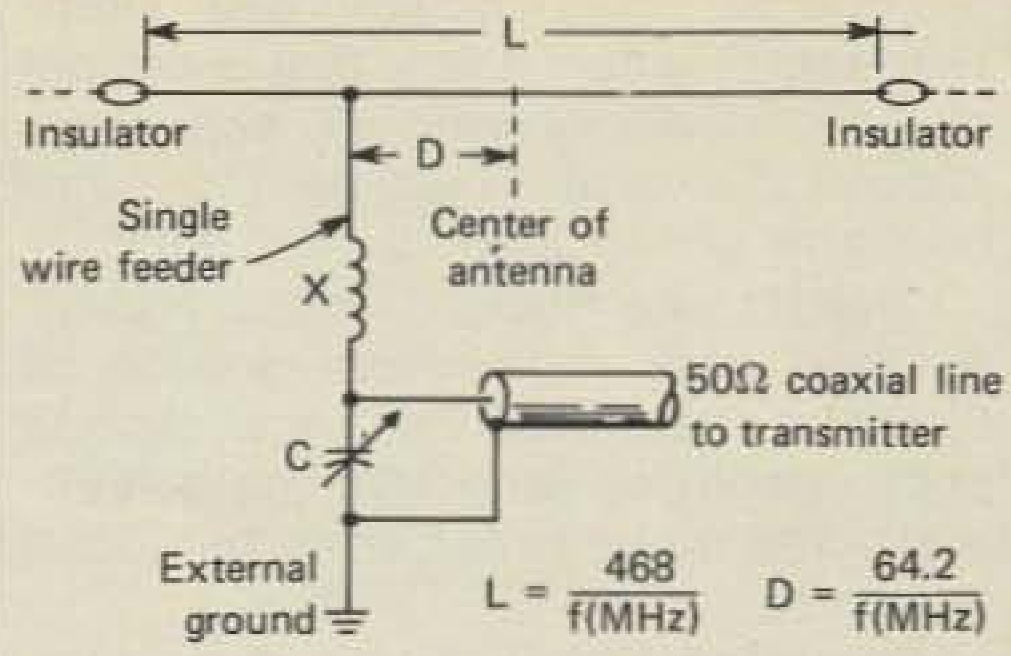
"Hence this theory is postulated: Radiation is largely due to reflection.

"In the previous discussion it has been shown that reflection always produces standing waves, and consequently the test for the absence of radiation on a transmission line is the absence of standing waves."

There was a long silence then Pendergast said flatly, "I don't believe it."

"What do you mean you don't believe it?" I demanded.

"I don't believe it," he said again. "It's *impossible* for a single wire carrying r.f. current not to radiate! Look! How about the rhombic an-



BAND	L	D	X	C
1.8MHz	260' 0"	35' 6"	16.0µH	480pf
3.7MHz	126' 6"	18' 0"	8.0µH	240pf
40.0MHz	66' 0"	9' 0"	4.0µH	120pf
20.0MHz	33' 0"	4' 6"	2.0µH	60pf
15.0MHz	22' 3"	3' 0"	1.5µH	45pf
10.0MHz	16' 0"	2' 3"	1.0µH	30pf

Fig. 3—The single-wire fed antenna of 1929 adapted to modern 50 ohm feed system. This antenna also works well on the second harmonic.

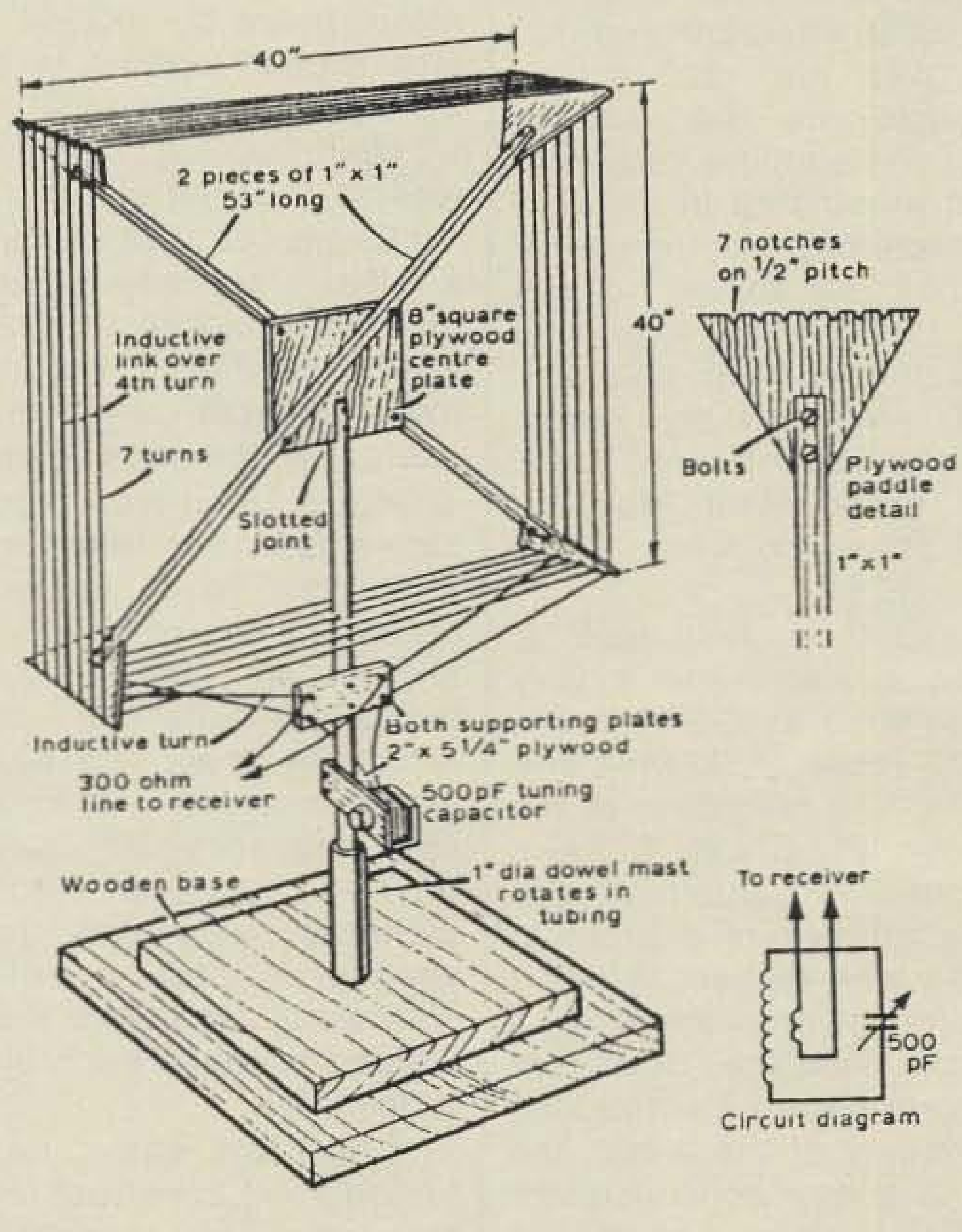


Fig. 4—Construction details of a loop antenna for operation on 160 meters or the broadcast band and capable of providing a deep null on interfering signals. (Electronics Australia via Radio Communication journal).

tenna? That's terminated and has no standing waves on it, and yet it radiates! How about that?"

"You bring up an interesting point," I admitted. "Was the 1929 article about the single-wire fed antenna correct? Does the single-wire feeder radiate if it is terminated in the correct load impedance? Maybe one of our readers has the answer to this puzzler. If so, I'll be happy to put his remarks in a forthcoming column."

"Very well," rejoined my friend. "I'll reserve my opinion until later. I'll bet your friend Walt Maxwell, W2DU, could solve the whole thing instantly!"

"In the mean time, let's look at the mail once again. I see a very interesting comment by G6XN in the February, 1977 issue of *Radio Communication*, the fine magazine of the Radio Society of Great Britain. Speaking about Quad antennas, G6-XN warns the readers of a problem that has arisen with respect to using untreated bamboo crossarms in a Quad. He says that the Quad antenna has a very strong electrostatic field in the vicinity of the arms, and that bamboo is a *very poor* insulator when wet. G6XN uses polythylene line to tie his Quad wire to his bamboo crossarms in such a way that the wire does not touch the bamboo."

"Interesting," commented Pendergast. "I would think that a couple of good coats of varnish, especially around the wire holes on the bamboo arm would also do the job."

"Well, I like *fiberglas* arms myself. A good and inexpensive source of fiberglas poles is the local sports shop. Used, or defective, pole-vaulting poles make great arms for Quad antennas."

Pendergast smiled and picked up the copy of *Radio Communication*.

"Look here!" he exclaimed. "Here's just the ticket for the forthcoming fall and winter 160 meter DX work. An inexpensive receiving loop (fig. 4) is a great device for nulling out local Loran interference or strong local signals.

"The loop has 100 feet of #22 insulated wire, and the frame is 40 inches on a side. This works out to 7 turns. The loop is tuned with a 500 pF capacitor and covers the broadcast range as well as 160 meters. The pickup loop is one turn coupled to the receiver with a short length of TV ribbon line.

"The tuning capacitor on the loop is resonated for maximum signal then the loop is turned about, either for maximum signal or for a null."

"Well, now is the time to get ready for next winter's DX season for the low frequency bands," I replied. "By the way, did I ever show you the article on a home-made 40 meter rotary beam by VK3BM in the *Amateur Radio Journal* of the Wireless Institute of Australia?"

"No," replied my friend. "What was so unusual about it?"

"Bruce, VK3BM, decided to build a full-size 40 meter rotary beam. His problem was how to adjust and tune the beast when it was atop a 90 foot tower without using the motorized ladder of the local Fire Brigade!

"His solution was to use untapered elements and a tuned feed line. Experiments have shown that when tapered elements are used, especially on 40 meters, where the elements are quite large and the taper is usually great, the beam may end up as much as 400 kHz off the design frequency. So VK3BM used untapered elements made of 2-inch diameter aluminum tubing. Light weight tip sections of telescoping size were used, and the joints were *welded* to make each element a one piece affair.

"The boom was made of triangular lattice steel construction and was 40 feet long. This gave 20 foot spacing between elements. The reflector was 70'3" long, the driven element 66'7" long and the director was 61'5" long —all cut to a design frequency of 7020 kHz."

"How did he feed this monster?", asked Pendergast, as he copied the dimensions into his notebook.

"Bruce said that he couldn't envision himself adjusting a matching device while he was hanging by his heels 86 feet up in the air. So he split the driven conductor of one of a pair of 50 ohm coaxial lines. The outer, braided conductors of the line were grounded together and to the frame of the beam.

"The element halves were supported by slipping short lengths of polyethylene tubing over the inner ends and clamping them to a short length of hardwood, which served as a crossarm.

"The feedline, then, is a side-by-side pair of 50 ohm coaxial cables, which form a shielded, 100 ohm balanced line. This is a low-loss arrangement that does not radiate. The radiation resistance of the beam is about 35 ohms, and this shows up as a s.w.r. of about 3-to-1 on the line. At 7 MHz, this value of s.w.r. does not contribute significantly to feedline loss, which is very low."

"And then he used an antenna tuner at the bottom end of the line so he could match up to a 50 ohm coaxial line", exclaimed my friend.

"That is correct", I said. "On the first day the antenna was up, VK3BM worked a group of W5 stations and got reports ranging up to S9 plus 50 dB! That's a real potent signal for only 200 watts PEP input on 40 meters!

"This design is a good example of trade-offs. VK3BM didn't want to have to adjust the antenna once it was atop the tower. To achieve this goal, he used untapered elements which he could cut to formula and then used a feed system which required no adjustment at the antenna. Thus, he could assemble the beam on the ground and place it atop the tower with the assurance that it would work right off the bat.

"To achieve this end, he had to use large elements, fairly wide spacing and a heavy support structure. The beam must have been quite heavy, but if it is properly built, and the tower and rotator can stand the load, that's no big problem".

"Its an interesting concept", agreed Pendergast. "I have heard that tapered elements have to be longer than untapered ones, but nobody seems to know the amount of lengthening that is required for a given taper. It looks as if VK3BM neatly sidestepped this problem". ■

a monthly feature by

WILLIAM I. ORR, W6SAI

Antennas

Design, construction, fact, and even some fiction

Pendergast uttered a mild oath and gently removed his headset and placed it gently on the desk. "For the life of me," he said, "I don't know how *anybody* receives *anything* on 160 meters during the summer." He turned up the receiver volume and a blast of static shook the 'phones.

"Think how bad it must have been on 1,000 meters in the old days," I remarked. "Cheer up. The static level will drop soon, and the fall DX season for 160 meters will be upon us. In fact, since the band is so noisy, I think now is a good time to start planning your 160 meter antenna. Do you have any ideas?"

"No," admitted my friend. "I just don't know where to start. Do you have any good suggestions?"

"When in doubt, consult the expert," I replied. "In this instance, my expert is the Dean of 160 meter DXers—Stew Perry, W1BB. Stew has graciously provided me with some good information on 160 meter antennas that he and other prominent DXers use on the 'top band,' Would you like to hear about them?"

*48 Campbell Lane, Menlo Park, CA 94025

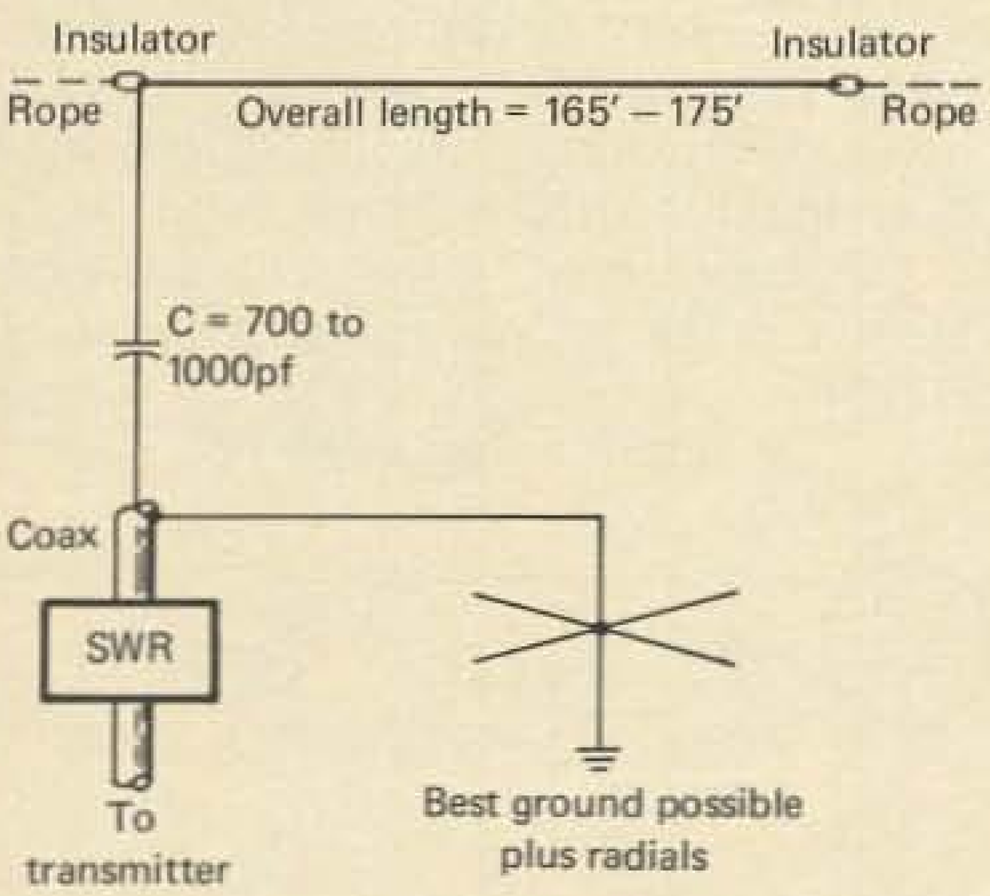


Fig. 1—The antenna recommended for the 160 meter beginner by W1BB is the Inverted-L. Slightly more than a quarter-wavelength long, the Inverted-L presents a good impedance match to a 50 ohm feed system. Resonance is established by means of the series capacitor. Antenna may be bent if it is required to place it in a small space. At least one ground radial (135 feet long) is required. More radials give improved performance. Radial can be insulated hookup wire laid along the surface of the ground (or slightly above it) and can run through bushes, etc.

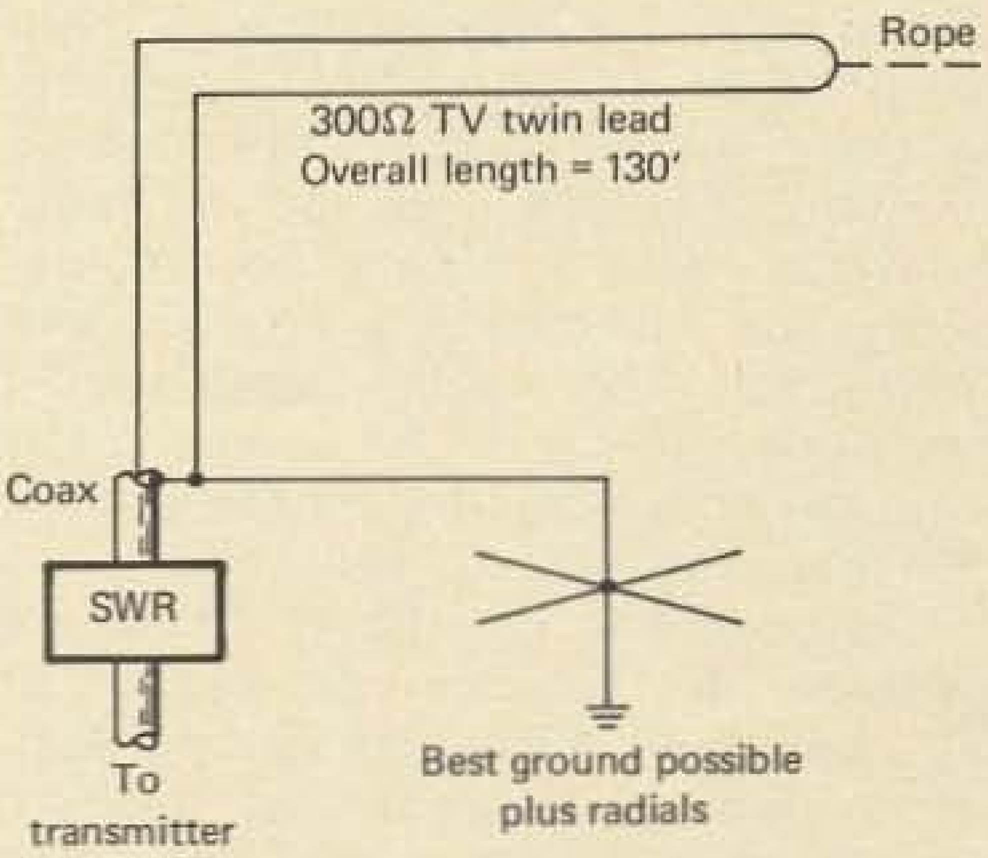


Fig. 2—The Folded Marconi antenna for 160 meters. Described first by Bell Telephone Laboratories in 1949, the antenna was featured in the December, 1953 issue of CQ magazine (page 58). The antenna is made of TV "ribbon" line, but may be made of two parallel wires, with air insulation, as the impedance of line has nothing to do with antenna operation. Antenna length is pruned for lowest SWR at the design frequency. One-third of the antenna should be run as vertical as possible.

"Yes, yes," exclaimed Pendergast eagerly, as he opened his large notebook and prepared to take down the data.

"Well, I'll paraphrase Stew's letter. His opinion is that the best antenna for the 160 meter beginning enthusiast is the *Inverted-L* shown in fig. 1. This antenna is about 165′ to 170′ in overall length. The vertical section is as high as possible, with the remainder of the antenna running horizontally to a convenient tie-point. The vertical section does most of the work. The antenna is adjusted to resonance by a variable capacitor connected in series with it. The capacitor can be a two-gang broadcast unit with the sections in parallel, or what have you. It is fed with a 50 ohm coaxial line through an SWR meter. Stew says it will be great for local contacts even with a poor ground, but the better the ground connection, the better it will perform.

"As to the ground connection, Stew says to tie onto water pipes, wire fences, lay down quarter-wave radials of insulated wire and use *multiple* ground rods. You can use it with a poor ground, and then improve the ground as you go along. The better the ground, the better the results."

I handed Pendergast a second drawing (fig 2). Here's a sketch of a well-known 160 meter antenna. It is a *Folded Marconi,* first described in the *Bell Telephone Laboratories* "Record" of May, 1949. This two-wire antenna, if completely vertical, would have a base feed point impedance of about 145 ohms. When it is bent into an L-shape the impedance is lowered. Experiments have shown that if the vertical section is about one-third as long as the horizontal section, the feed point impedance is very close to 50 ohms. That makes the vertical section 43 feet high and the horizontal section 87 feet long, for an overall length of 130 feet. A 50 ohm transmission line is used, along with an SWR meter.

"The antenna can be made up of 300 ohm twin lead, since the imped-

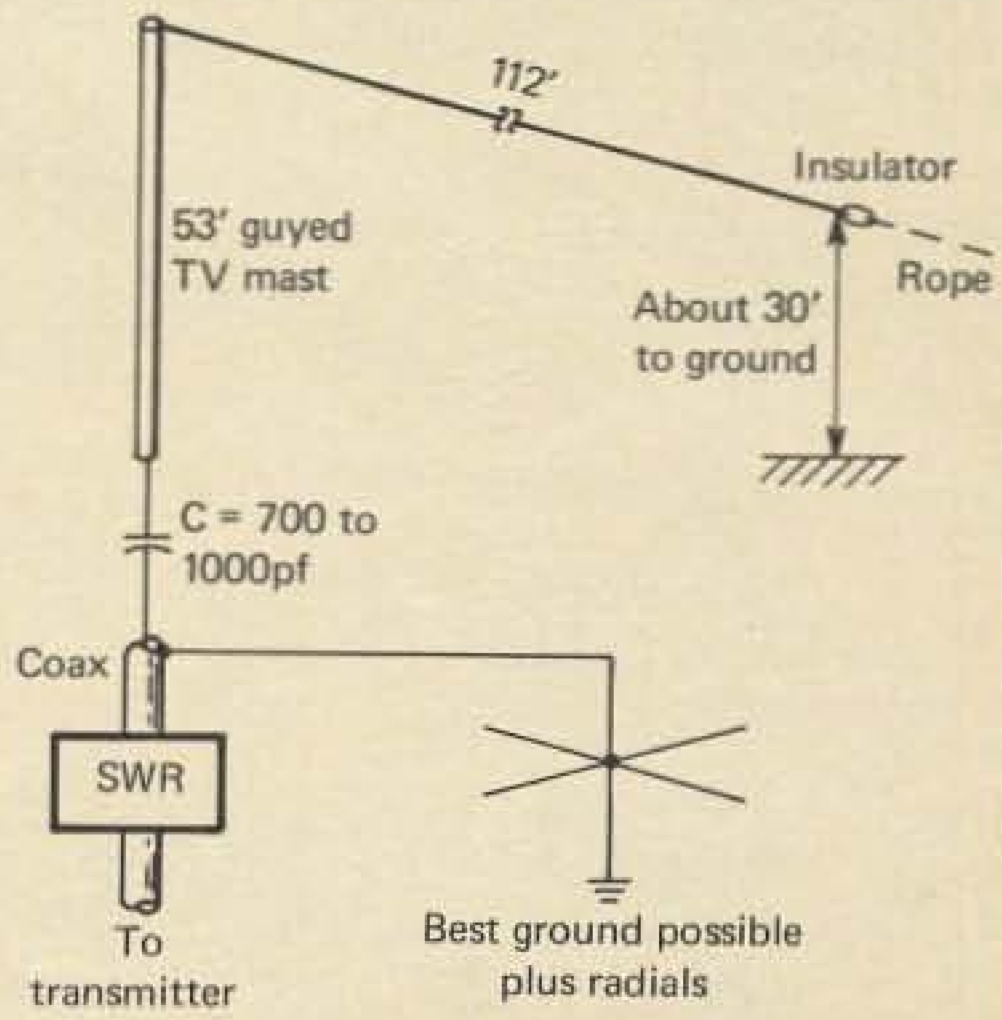


Fig. 3—The G3RPB version of the Inverted-L antenna. A TV mast is used for the vertical section, with top wire run down at an angle to the ground.

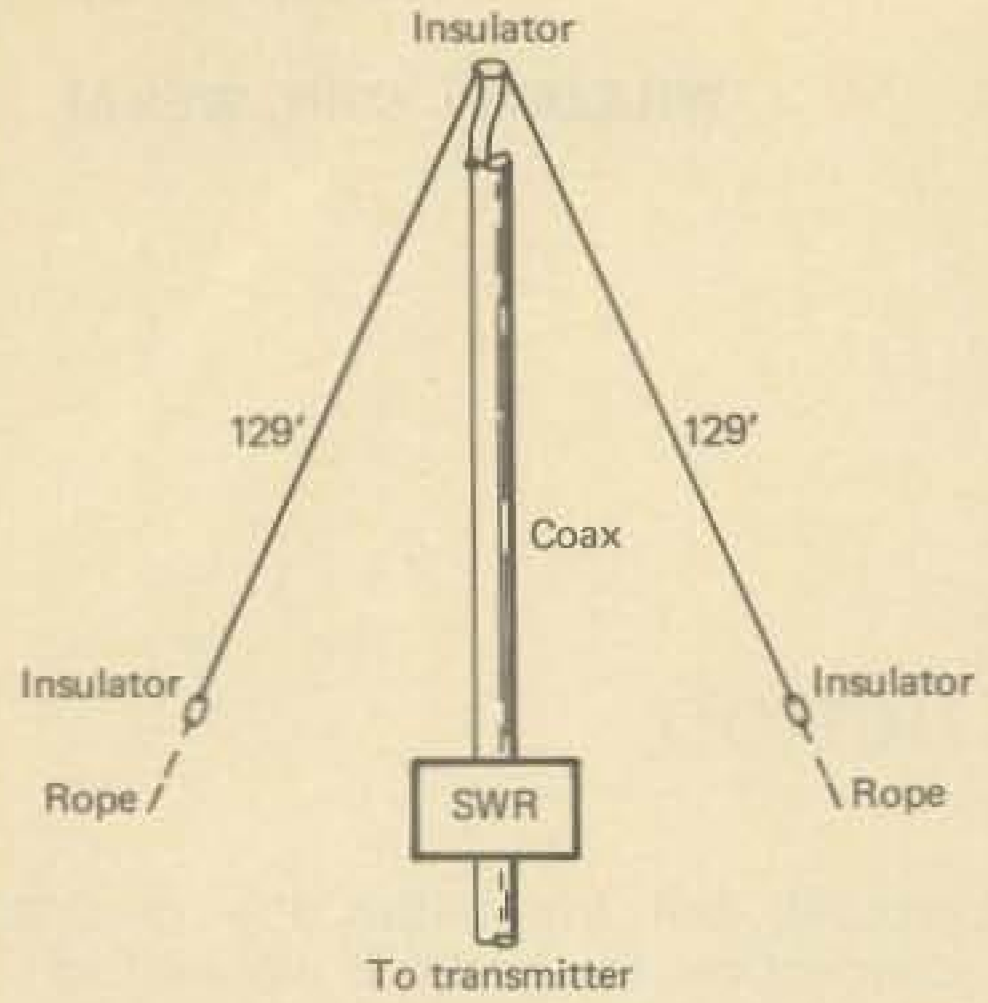


Fig. 4—The Inverted-V antenna used by W1BB for 160 meter DX. The wires are trimmed equally for best SWR at the operating frequency. The ends of the antenna are about 15 to 20 feet clear of the ground. The center of the antenna is at least 40 feet high, and works better if it is upwards of 70 feet high. If open wire line is substituted for the coaxial line and an antenna tuner is used, the antenna performs well on other high frequency bands.

ance of the twin lead does not enter into the picture. Again, the best ground system possible is very important WBGDQ, whose 160 meter signal is very impressive, has used this antenna for DX work.

"Stew says this antenna compares very favorably with his full-size vertical in tests with mobile stations up to 100 miles distant in daytime, which shows the low angle radiation of the antenna. This design was also used by W0VXO on his South American and Caribbean DXpedition.

"A variation of the folded, or bent, antenna is the one used by G3RPB for his trans-Atlantic work on 160 (fig. 3): It is a version of the antenna in fig. 1. The vertical section is a 53 foot metal pole (TV mast) and the horizontal section is a wire. The overall length is about 165 feet. G3RPB uses buried copper objects (a water boiler, for example) for his ground, plus as many random length radial wires as he could lay down in his yard."

"Simple enough," remarked Pendergast. "But how about something a little more exotic?"

"Right. Well, Stew thinks the best all-around 160 meter antenna is an *Inverted-V* (fig. 4). He likes it because it provides radiation at many different angles, one of which is bound to hit the ionosphere for good propagation. For long distance DX, Stew says, the Inverted-V isn't quite as good as a high vertical used with a *good* (repeat, *good*) ground connection. For the average location, however, with soil of poor conductivity, the Inverted-V is an excellent performer. The center point should be fairly high (fifty to seventy feet) and the ends should clear the ground by fifteen to twenty feet.

"If operation on 160 is all that is wanted, the antenna can be fed at the apex with a 50 ohm coaxial line. If multi-band operation is desired, it can be fed with a two-wire open line of random length, and an antenna tuner.

"The ends of the Inverted-V are trimmed equally until a low value of SWR is achieved at the chosen frequency. For 1812 kHz, as an example, Stew found each wire was about 129 feet long."

Pendergast sighed. "It sounds as if the ground connection is the key to successful 160 meter operation."

"Yes," I replied. "Listen to this letter that ZE7JX (Rhodesia) sent to W1BB concerning his experience on 160 meters. Peter says he had a 265 foot wire, about 55 feet high for 160 work. It worked pretty well, but wasn't good enough. Peter wanted to work WAC on 160 meters and couldn't raise Europe, Australia or Asia, even on pre-arranged schedules.

"So he erected a 55 foot vertical, with a matching network at the base and laid out fifteen radials, each 130 feet long. The radials were placed on the grass. The antenna presented a load of about 4 ohms, so he spent a lot of effort matching the antenna. Once he got a low value of SWR on the transmission line, the antenna sounded "hot" on the receiver. He tried a CQ and raised EP2TW in Iran with a 449 report! Asia at last! Encouraged by this success, he went for Europe, but no luck. So he laid down 50 more radials and noted that the base antenna current increased considerably. A few nights later he raised G3SZA for a 559 report.

"This left only Australia for WAC. Night after night, schedules were held with VK6HD, with one failure after another.

"Finally, in desperation, 128 more radials were put down, for a total of nearly 200 radials. This amounted to something like *sixteen thousand feet of wire* either in, or atop the ground!

"However, the very next day after all this work, Peter worked both VK6HD and VK6IZ, followed by a VK3 a few days later!

"Peter says that with the present set-up, if a station is heard, a contact usually results!"

Pendergast gulped. "Sixteen thousand feet of radial wire." He thought for a moment then said, "I guess if you want something badly enough, and carry on to the end of the road, the results are worth the effort."

"It is mind-boggling," I replied. "But 160 meters is a very special band with very unique problems. Just listen to the summer static!

"Unfortunately, a vertical antenna is very noisy for receiving, especially

(Continued on page 88)

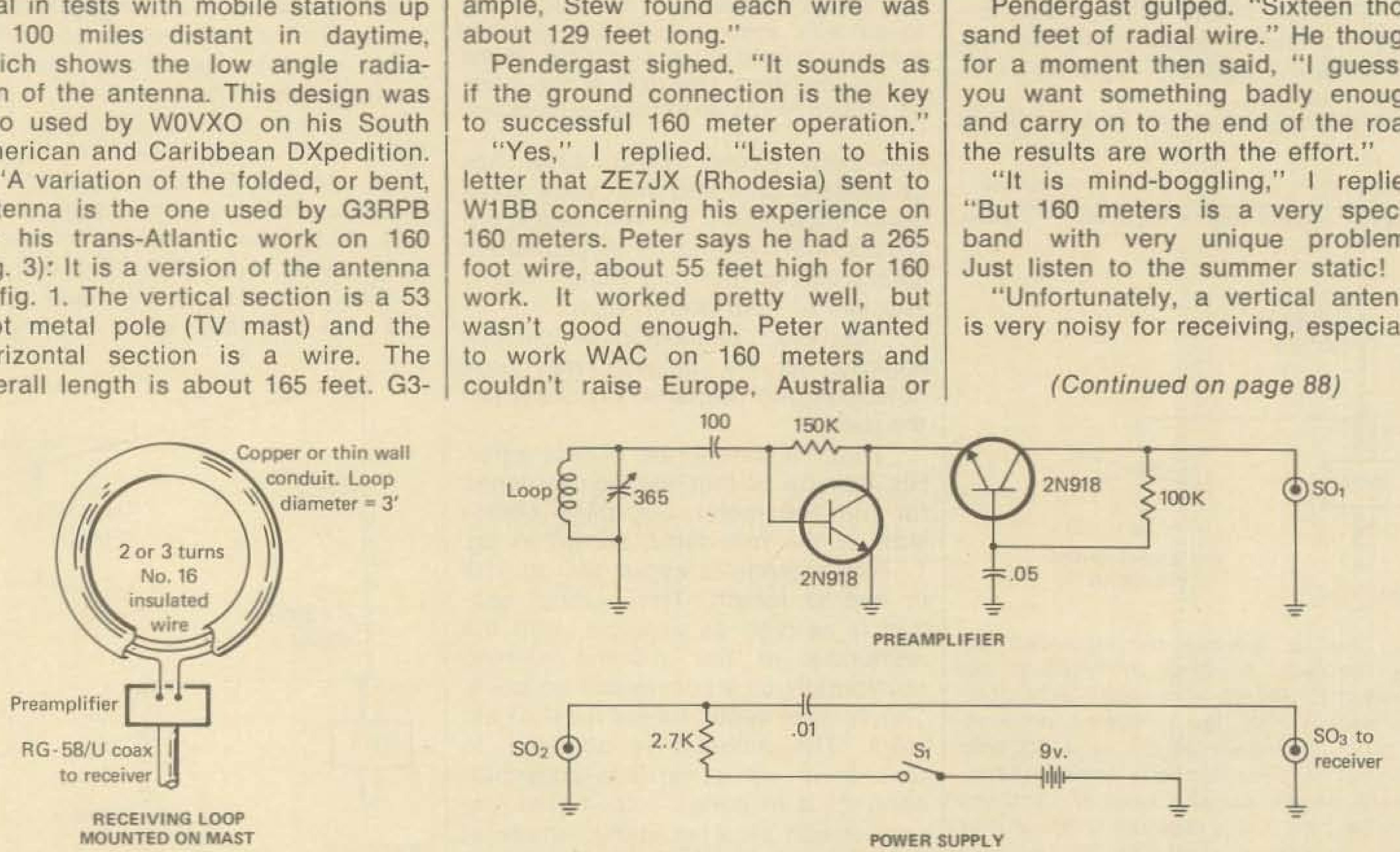


Fig. 5—The W7DOL/6 Loop and preamplifier for 160 meter DX reception. Loop is a 3-foot diameter circle of copper tubing or conduit. If a metal support mast is used, it is grounded to the mast only at the top. The bottom of the loop is insulated from the mast. Two or three turns of wire are passed through the loop and are resonated to the receiving frequency by the 365 pF capacitor in the preamplifier, which is mounted directly beneath the loop. The capacitor may be a mica compression unit. The preamplifier receives its power through the coaxial line which connects it to the receiver.

Antennas *(from page 64)*

if you are looking for weak signals. And most 160 meter DX signals are weak. Stew says if you use a vertical antenna for receiving, in a noisy location—like a city—it is very bad. In the country it is tolerable. Horizontal antennas, on the other hand, are much quieter and reject a lot of noise, but don't have the "Moxie" for the weak signals. He feels that any station using a vertical antenna should have a stand-by horizontal antenna for receivinig, with means to quickly switch from one to the other.

"In addition, W1BB says that the *greatest* asset for a 160 meter DXer is a quiet location. The DXers who do the best work all live in the country as far away from man-made noise as possible. Stew notices the difference. He lives near Boston under a blanket of "electronic smog" with a noise level that varies from S3 to S7, even under the best conditions.

"Stew also has a second location —a 35 acre farm in Maine—which is over 7 miles from the nearest little village with a population of 500. He says it is Heaven to operate from there.

"In summary, W1BB says that it is important to be away from local interference and to stay away from vertical antennas for DX receiving. And Stew must know—he has well over 100 countries on that band!"

"What's the solution for noisy areas?" asked my friend, as he jotted notes into his large, black notebook.

"Stew says a lot of 160 meter DXers have turned to loop antennas to fight local noise. He likes this idea, but says that sometimes a loop antenna can be susceptible to broadcast cross-modulation in high signal areas.

"Stew recommends the loop antenna used by W7DOL/6 and others (fig. 5). This simple loop is only three feet in diameter and uses a two-stage preamplifier mounted on the loop. It is very effective in phasing out noise and Loran signals. It should be mounted about 20 feet, or more, above the ground."

"Well, if Stew could only put up *one* antenna for 160 meters, what would he put up?" inquired Pendergast.

"He says if he was limited to a single antenna, he would put up an Inverted-L, such as shown in fig. 1. It has both vertical and horizontal components of radiation and is not too noisy on reception. His second choice would be an Inverted-V, if it was high enough."

"And what would the super-DX operator, the Big Gun, use on 160 meters," asked my friend.

"According to W1BB the most effective antenna for transmitting is a quarter-wave vertical tower, with a *large* system of radials under it. The antenna should be very close to the seashore, or located on marshy ground. The number of radials should be at least 200, or better.

"The super-DX operator would also have a number of receiving antennas. At one time W8LRL, an outstanding 160 meter DXer, had 11 receiving antennas. W1BB usually has four different ones. Unexplainably, 160 meter signals sometimes come in better on one antenna than on another one and you can never be sure which one is best. Once W1BB found that the European signals were coming in best on a 160 foot piece of wire *laying on the ground!*

"No doubt, the best 160 meter locations are close to the water, but inland DXers do a great job, in spite of the handicap they work under. They make up for the lack of seaside conditions by placing *plenty* of radials under their vertical antennas.

"The 160 meter band is the perfect place for testing unorthodox antennas. Remember all those "April Fool" articles in the past about underground antennas? Well, some fellows use them for receiving on 160 meters. Claim they cut down the noise more than they drop the signal, so you get a better signal-to-noise ratio.

"And I understand that KV4FZ experimented with an *underwater* receiving antenna. He heard ZE7JX on it during a test. Stew, W1BB, tried a 200 foot underwater antenna and heard VR3AH with a very good signal-to-noise ratio. Stew also tried a fence wire as a receiving antenna. It was a couple of hundred feet long and about 3 feet above the ground. Excellent results, he says."

Pendergast said, "I understand some fellows have 160 meter beams up in the air!"

"That's right," I replied. W1BB has a two element, Inverted-V bidirectional beam. He says he consistently gets one to two S-unit improvement with it on transmitting as compared to a single Inverted-V. And that's a lot of gain on 160 meters!"

"To sum it up, then, you need a quiet location for 160 meter DX so you can hear it. Then, you need a good, low-loss transmitting antenna. This usually means a vertical (loaded, probably, to save height) with plenty of radials, or a high inverted-V. The beginner, or 160 meter operator interested more in rag-chewing than DX, can profitably put up an end-fed wire (with a *good* ground connection) and do a good job. So the problem isn't insurmountable. And with more 160 meter sideband operation, it's a cinch that the band will be jumping this fall," concluded Pendergast.

"I couldn't have said it better myself," I remarked. ■

Math's Notes *(from page 57)*

of the amplifier is adjusted so that the output is at the required level.

Referring to the discussion on op-amps in MATH's NOTES a few months ago, one should remember that the ratio of feedback resistor and input resistor in an op-amp determine the gain. Using this fact, the feedback resistor can be shunted or placed in series with a capacitor to achieve filtering action also. Again, in fig. 4 (a) shunting the resistor gives a low pass configuration where 50% frequency is the frequency. Where R_f is equal to the capacitive reactance of the shunting capacitor. In fig. 4 (b) a capacitor is placed in series with R_f. High pass filtering is the result. Note that this configuration does not have a DC feedback path and as a result will have no gain.

Finally, in fig. 5 we have presented the universal, single stage, low-pass or high pass relative gain chart. This chart will help understand the degree of filtering that can be achieved by the simple circuits given. To use the chart, one only has to determine the cutoff frequency (50% frequency). Then, at frequencies above or below cutoff, the relative gain can be determined.

The applications of the two filter configurations given here is straightforward. They may be used over the range of DC to a few megahertz and will only give non-calculatable results when stray inductances and capacities of significant values are present.

73, Irwin, WA2NDM

a monthly feature by

WILLIAM I. ORR, W6SAI

Antennas

Design, construction, fact, and even some fiction

"I still can't get over the idea of using an underground receiving antenna," exclaimed Pendergast. He slipped the earphones off his head and rubbed his ears, which were still ringing from the rifle-shot QRM that filled the 160 meter band during the warm, daylight hours. "And I don't understand how anybody can hear anything through this summer QRM," he added.

"It should be dropping off by now," I replied. "Wait until October. Things will be better by then.

"By the way, here's W1BB's 160 meter newsletter. It has some information on underground antennas. And they're not a joke. According to the newsletter, K7LFY uses one, and has done so for over two years. According to K7LFY they improve the signal-to-noise ratio, eliminate a lot of vertically polarized noise and reduce local ground wave signals. All of this makes the underground antenna a good receiving antenna for weak DX signals. Bob uses buried dipoles which are about one to four feet below the surface. The optimum length works out to be only about 0.33 of the free space length. Thus, for 1825 kHz, the underground dipole is only about 85 feet long overall. And, interestingly enough, the dipole seems to be directional off the ends. What do you think about that?"

"From what I hear, the whole idea of underground receiving antennas seems controversial. Some fellows have had no luck with them. Maybe it depends upon soil conductivity. In any event, they're cheap and easy to install. It may be interesting to try one out for 80 or 160 meters this coming winter DX season."

"Right," I replied. "I understand that W7QID has had good results with an underground receiving antenna for trans-pacific DX. So we have a lot to look forward to. The last word hasn't been said yet about these funny antennas.

"Before we leave 160 meters, you might be interested in these two antennas recommended by W1BB," I said. "The first one is a simple Beverage wire for receiving. It was used by Paul Godley at Androssan, Scotland in 1921 for the very first reception of trans-atlantic amateur signals. And some 160 Meter DX enthusiasts still use it today (fig. 1). It is directional off the far end. Basically, it is a terminated long wire. The terminating

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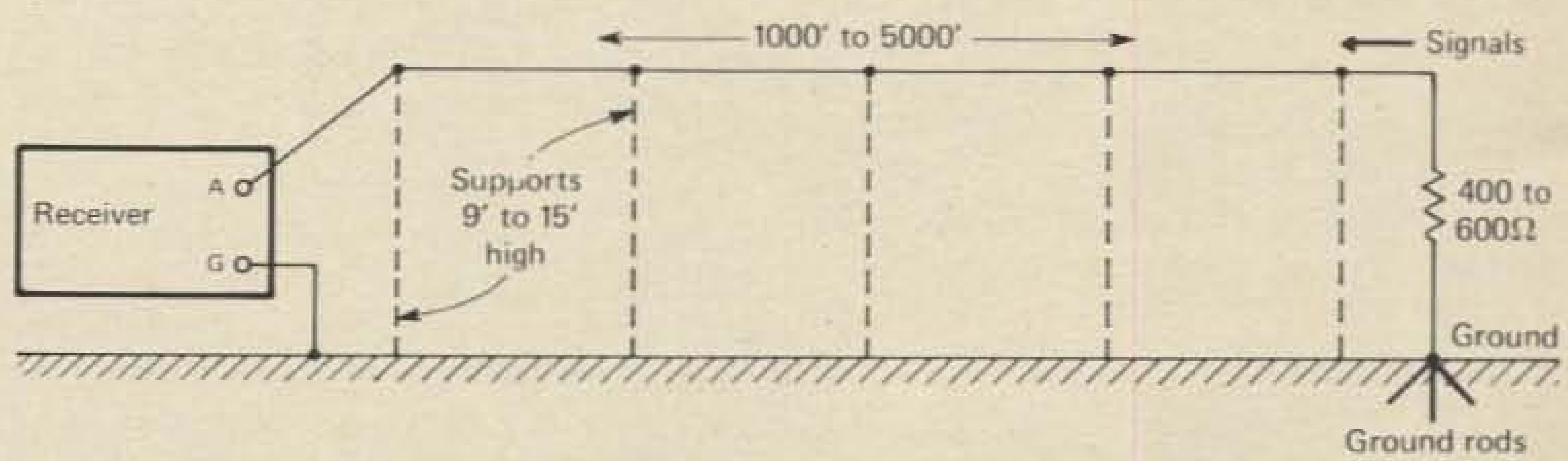


Fig. 1—The single wire Beverage antenna is useful for 160 meter DX. The directivity is from the far end towards the receiver. The antenna is terminated with a non-inductive resistor whose value can be varied to provide the best front-to-back reception ratio.

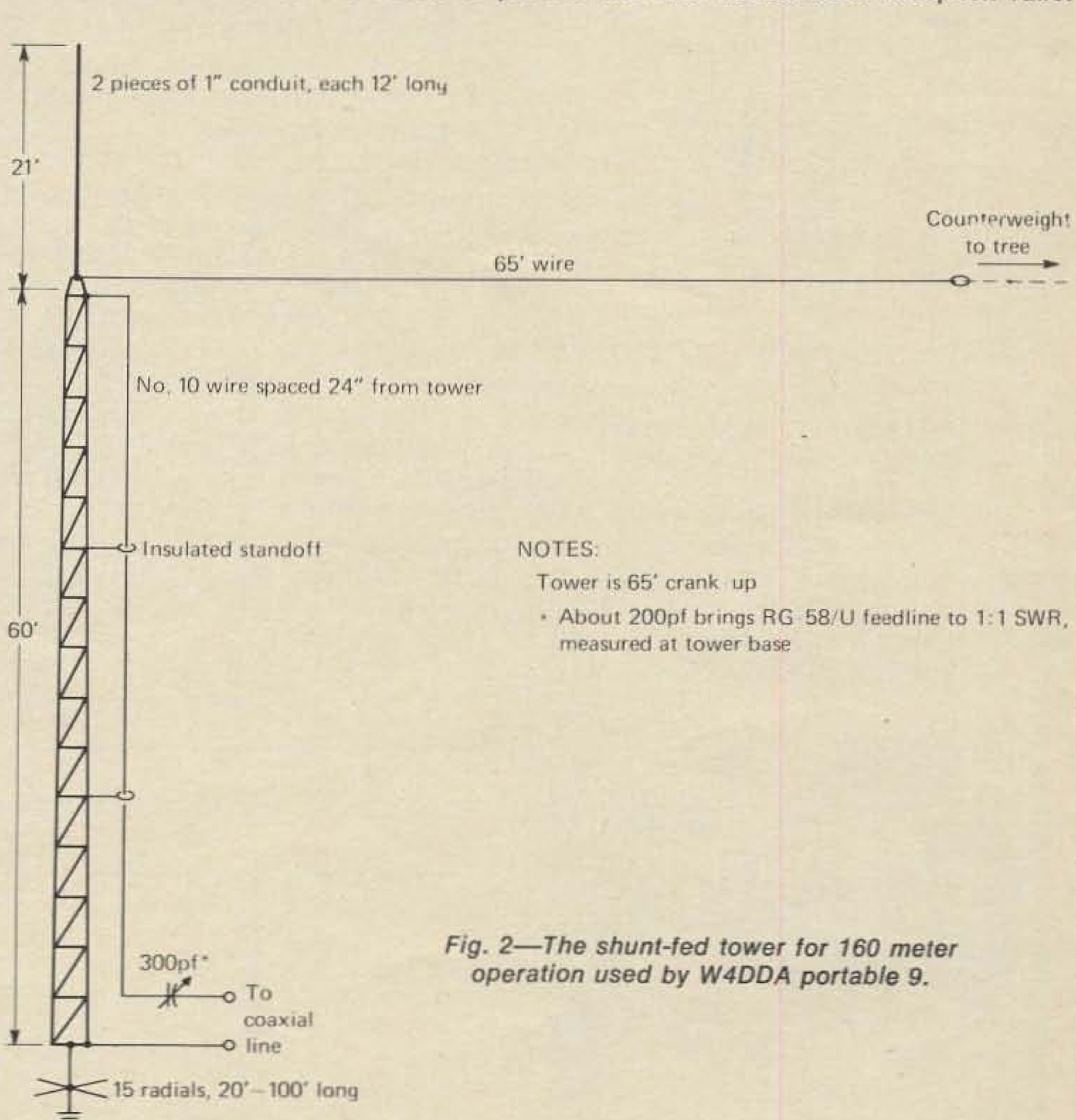


Fig. 2—The shunt-fed tower for 160 meter operation used by W4DDA portable 9.

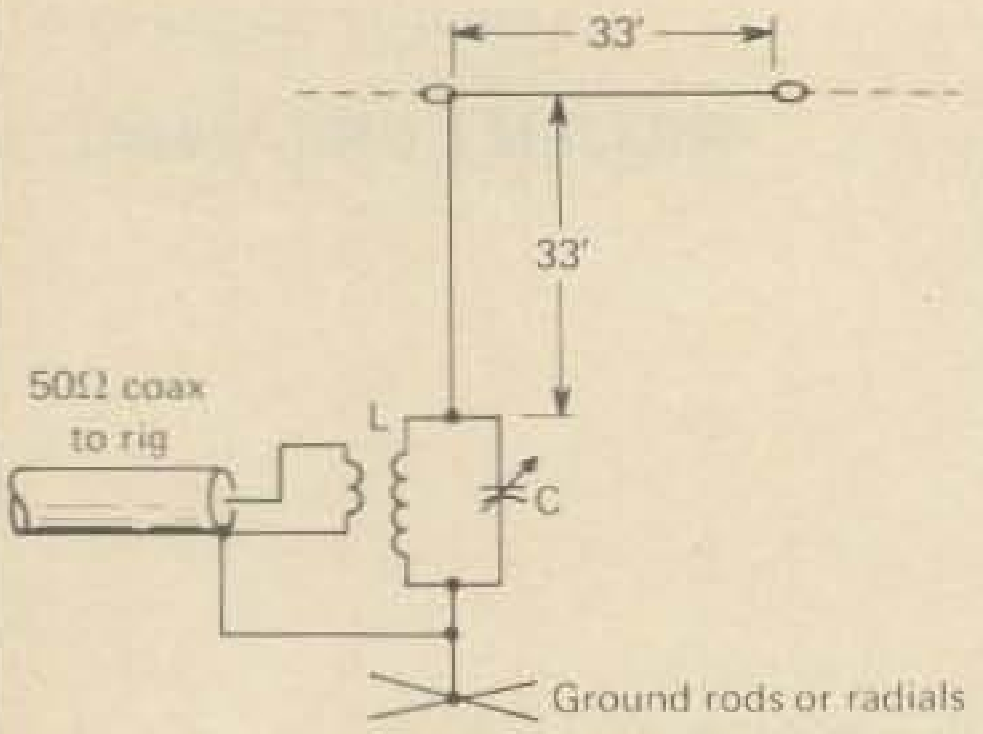


Fig. 3—The 40 meter antenna of W5AG. The L-C circuit resonates to 40 meters. W5AG suggests the use of an old pre-war Barker and Williamson end-link 75 watt plug-in coil.

resistor can be varied for best front-to-back ratio. It takes a lot of space, but it could be run along a fence, or something like that.

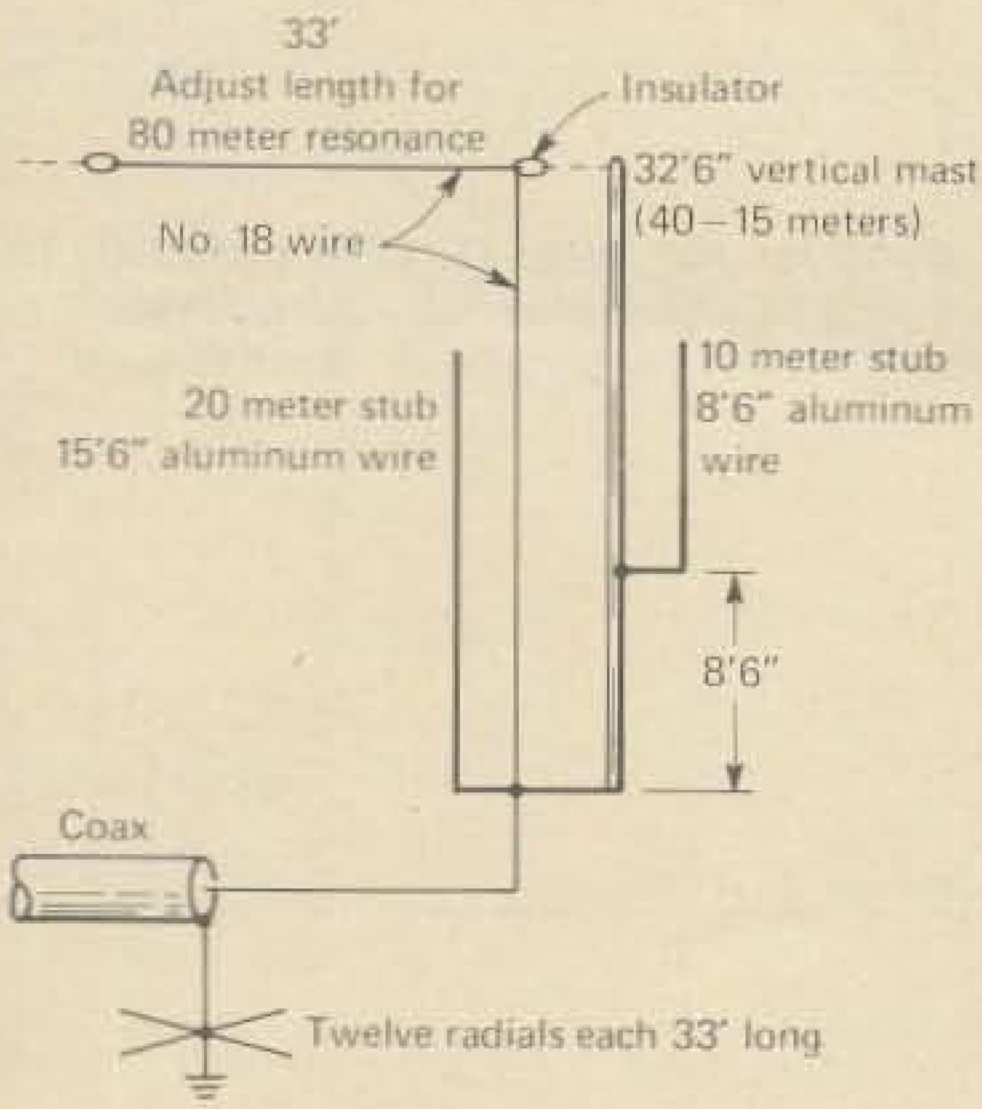


Fig. 4—The new multiband antenna at WA3GJA for 80 thru 10 meter operation.

"The second antenna probably appeals to more DXers as it can be erected on a small lot. Basically, it is a shunt-fed tower, with a top loading wire (fig 2). This antenna is used for 160 meter DX by W4DAA/9 who really puts out a potent signal on that band."

My friend sighed. "It seems to me that 160 meter DX antennas are a formidable undertaking."

"They can be," I agreed. "Ernie, K1PBW, has two 110-foot, phased vertical antennas over an extensive ground plane. He can switch the phasing and gets a front-to-back ratio of nearly 18 db. And Earl, K6SE, uses a similar setup. They use lots of radials. Plenty of height. And plenty of DX-know-how."

"Well, how about the rest of us?", demanded Pendergast. "How about the feller with a poor ground, and not much space in the back yard?"

I looked at the mail on the desk. "Here's a letter from Sam, W5AG. He's got a very simple antenna for 40 meters. He says it is a variation of the old "30 up and 30 out" used by DXers in the "thirties." It gets the current point up in the air and has very low ground loss. Basically, it is a full-wavelength L-antenna, fed at the bottom (fig. 3). Sam says a superground is not needed, as the ground current is very low. He uses three ground rods. The tuned circuit is resonant at the operating frequency and antenna dimensions are not critical. It should work well for either 40, 80 or 160 meters."

"Nice," exclaimed Pendergast. "I can understand this!"

"And here's a simple antenna for 40 and 15 meters," I remarked, drawing a quick sketch in my logbook. A 40 meter dipole really doesn't work very well on 15 meters, even though it is supposed to. This design, shown in the Japanese magazine, *CQ-Ham Radio* is claimed to provide good results on both bands. Note that it is a loaded dipole for 40 meters, wih the a tip section electrically disconnected for 21 MHz operation by the inductor. The s.w.r. is less than 1.6-to-1 over both bands. I would think that this would make a nice DX antenna for Novices.

"I also received a note from Mike, WA3GJA, who comments on his antenna, which I discussed in the August, 1976 column. Since then, Mike has been doing more work on his installation, and has ended up with the antenna shown in fig. 4. This antenna works on all bands between 80 and 10 meters with no traps or loading coils. It uses tuning stubs, much in the manner of the Hy-Gain "Hi-tower" antenna system. Basically, Mike's antenna is a 40 meter vertical, which also operates on the third harmonic for 15 meter work. Connected in parallel with it is a quarter-wave wire for 80 meters. The wire runs up the 40 meter antenna,

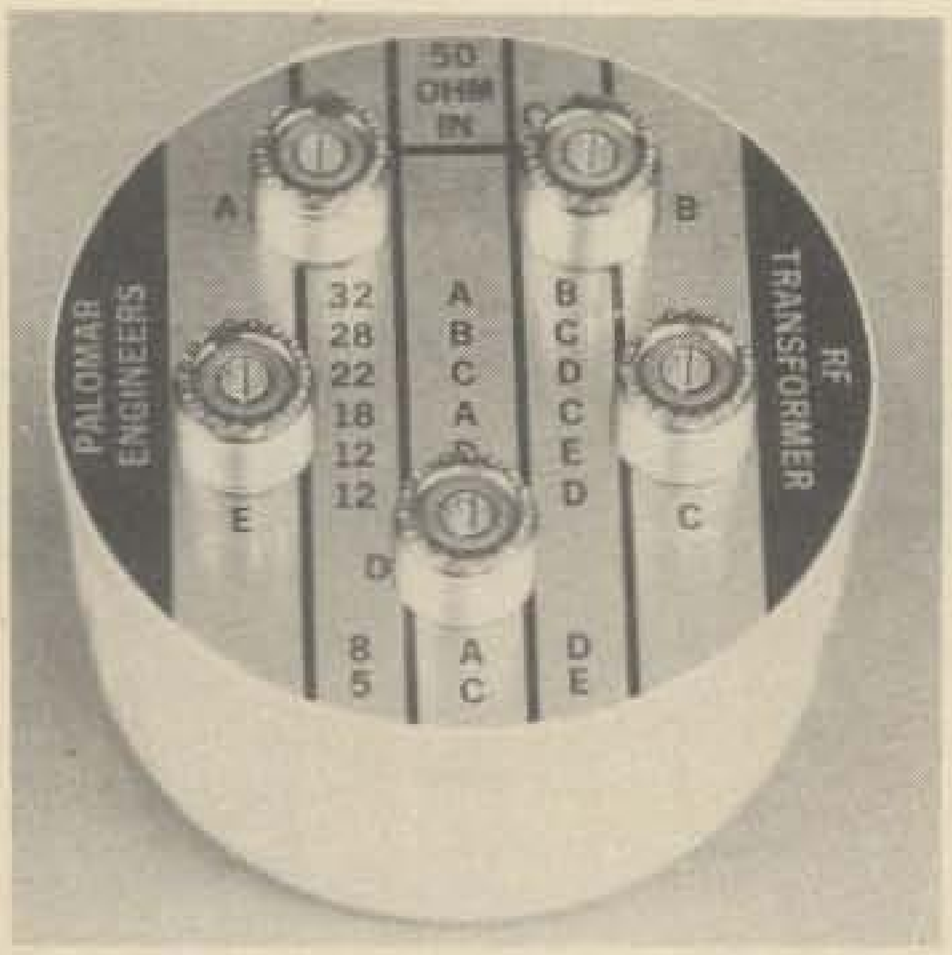


Fig. 5—The Palomar balun matches a coaxial line to load impedances of 5, 8, 12, 18, 22, 28 or 32 ohms.

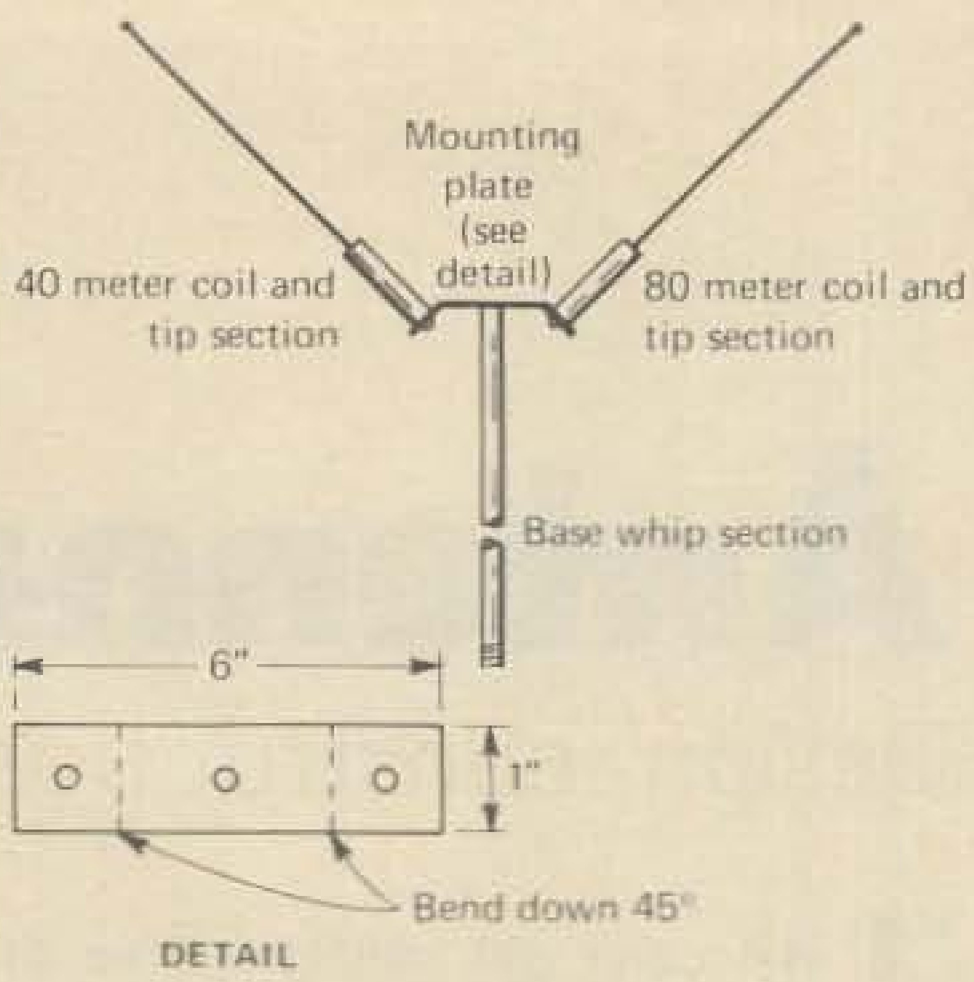
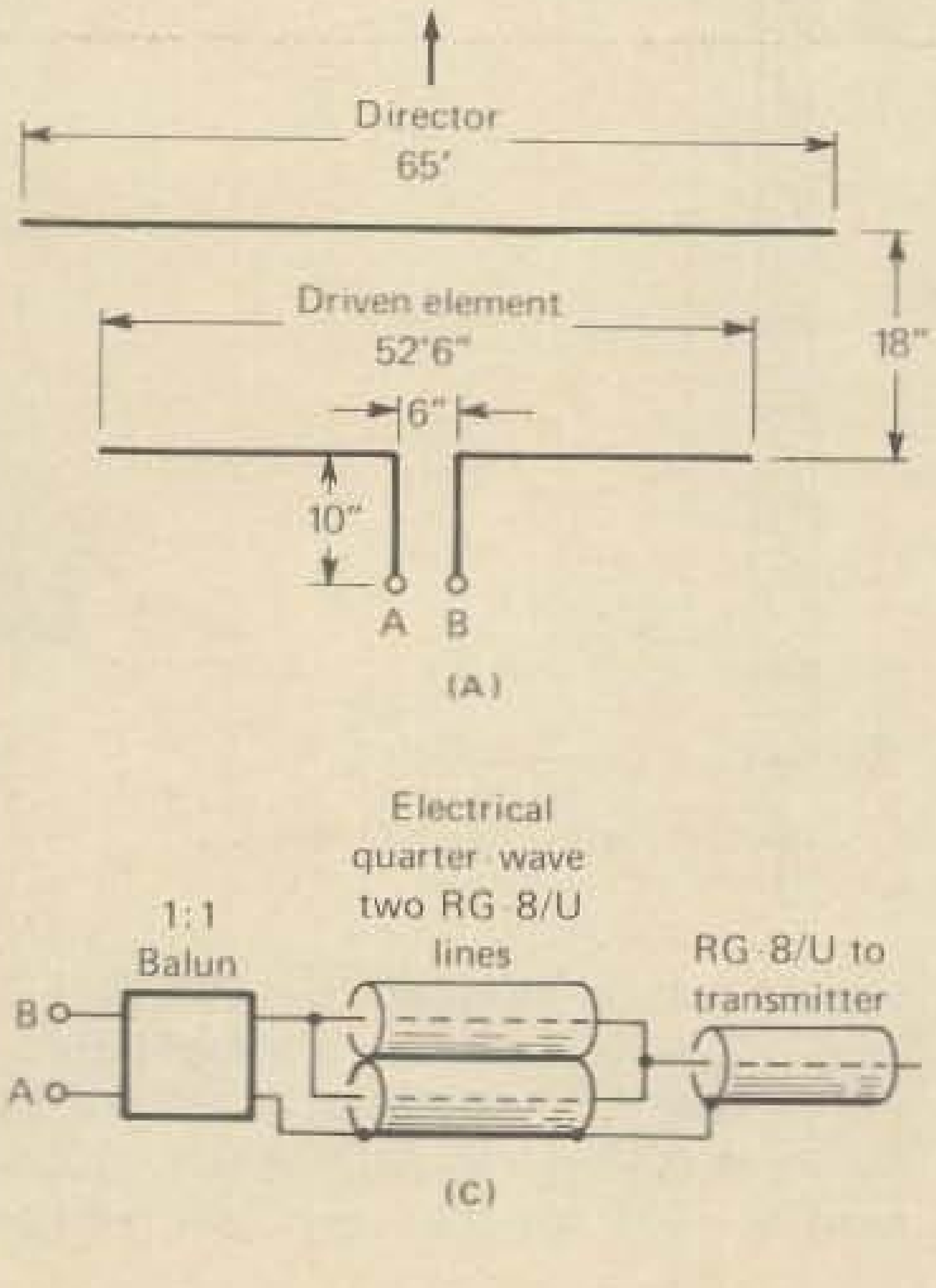


Fig. 6—Two band operation with a modified mobile whip antenna. Separate antenna tips and loading coils are mounted to a base whip section by means of an aluminum mounting plate. The plate measures 6" x 1". The tip sections are adjusted for proper resonance.



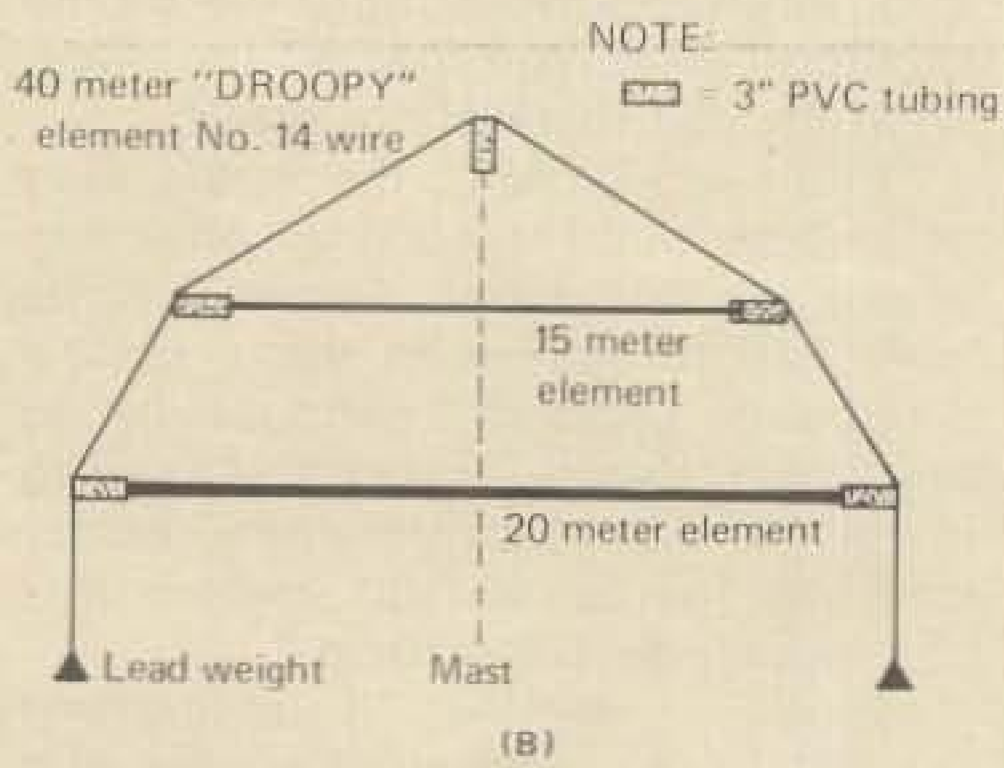


Fig. 7—The W6RRT "droopy beam" antenna for 40 meters (Courtesy of The National Contest Journal). (A)—Length of wire elements. (B)—Physical layout of the beam. (C)—Feed system.

which is made of three sections of aluminum TV mast. The wire is held free of the mast by means of TV-type "eye" insulators which are strapped to the mast. The wire then runs from the top of the mast to a nearby tree.

"Separate stubs are attached to the mast at the appropriate points to provide resonant elements for 10 and 20 meters. The stubs are made of wire and are held in position by the TV "eye" insulators. Mike uses aluminum TV ground wire for the stubs and makes sure that the top of the stubs—which are "hot"—are in the clear and that the TV stand-off insulators are placed a foot or two down from the top of the stub. Stub length is trimmed for best s.w.r. on the individual band.

"At the bottom of the antenna, Mike has laid out twelve radials, each 33 feet long, on the ground. He feeds it at the base with a 50 ohm coaxial line through an s.w.r. meter."

"I wonder if he gets a good match on each band?", murmured my friend, as he sketched the antenna in his notebook.

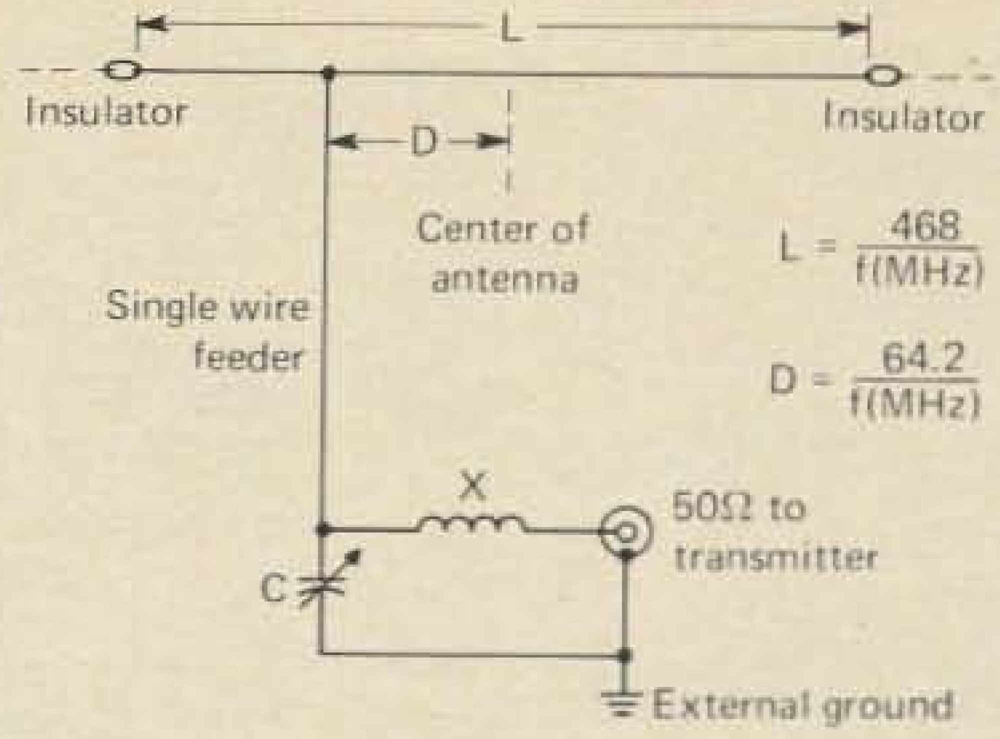
"I don't know", I replied. "But in any case, impedance matching on any multi-band antenna can turn out to be a problem. Its not bad on this type of antenna, but can get tricky with more exotic designs. You'll be interested in this new wideband transformer (fig. 5). It will match a 50 ohm line to load impedances of 5, 8, 12, 18, 22, 28 or 32 ohms, unbalanced. Now, that's not a bad deal at all! It will handle full power over the frequency range of one to 30 MHz. And its only about 3½" in diameter. And it is made by Palomar Engineers."

"It should be good for matching a mobile whip antenna, too", observed my friend.

"Yes, and that reminds me of a stunt that can be used for portable operation", I replied. "Some amateurs use a mobile whip antenna for portable operation when they are away from home, in a motel, or whatever. And this idea can work in a mobile home or in an apartment house where the landlord frowns on amateur antennas.

"Briefly, the idea is to mount two or more mobile loading coils and top sections on one whip base for multiband operation (fig. 6). The loading coil and top section for each band are mounted on an aluminum plate which is bolted to the top of the base section of the antenna. Each top section, in combination with the appropriate coil and base section makes up a resonant circuit which operates over a range of frequencies in a

(Continued on page 91)



Band	L	D	X	C
1.8MHz	160'0"	35'6"	16.0µh	480pf
3.7MHz	126'6"	18'0"	8.0µh	240pf
40 meters	66'0"	9'0"	4.0µh	120pf
20 meters	33'0"	4'6"	2.0µh	60pf
15 meters	22'3"	3'0"	1.5µh	45pf
10 meters	16'0"	2'3"	1.0µh	30pf

Fig. 8—The single-wire fed antenna of 1929 adapted to a modern 50 ohm feed system. This antenna also works well on the second harmonic.

Antennas *(from page 61)*

single amateur band. If two assemblies are used, the antenna combination will work on two bands. Some amateurs have used as many as four top sections.

"Best operation, of course, will occur when a good ground and a good match to the transmission line are achieved. Radial ground wires for each band can be made up of insulated hookup wire. The radial is a quarter wavelength long for the band in use. In a mobile home, the antenna can be mounted on the roof and the radial wire run down the outside of the home. The far end of the radial is "hot" with r.f. and should be insulated from ground and protected so that no one can touch it. It should also be held clear of nearby metallic surfaces, such as the siding of a recreation vehicle".

"The Palomar *balun* should work just fine with one of these antenna installations", observer Pendergast.

"That's right", I replied. "Sometimes you'll be surprised what a mobile whip will do in a semi-permanent installation, especially when a radial ground wire or two is used".

Pendergast reached in his pocket and pulled out a letter. "I've been meaning to give this to you for a couple of days", he said. "It is from Guy, WA4HVL, in Georgia. Guy read the remarks of Mike, W5IOB, in the April antenna column where he compared the DX results of a low Quad Loop to a ground plane antenna. Mike concluded that in the best direction for the loop, the ground plane outperformed it on DX contacts. This was on 40 meters. The ground plane base was about 28 feet in the air and the top of the Quad loop was supported on a 70 foot tower. And Mike ended up taking the Quad loop down.

"Well, Guy was mostly interested in stateside contacts on 40 meters. So he compared his Quad loop with his vertical ground plane antenna. The top of Guy's loop was about 45 feet in the air, and the base of his ground plane was about 5 feet clear of the ground. Now, out of 36 tests that Guy ran, switching back and forth between the two antennas, 28 stateside stations preferred the Quad Loop by as much as three S-units. Four stations preferred the vertical antenna, and four stations said the antennas were equal in performance."

"Very interesting", I replied. "It all hangs together. W5IOB tested the two antennas and found the ground plane best for DX. And the ground plane has considerable low angle radiation, suitable for DX. WA4HVL tested the two antennas on stateside contacts, which are mostly high angle skip. And he found that the Quad loop, horizontally polarized, was best. This antenna, of course, provides fairly high angle radiation. So it should be better for stateside contacts".

"Yes", Pendergast agreed. "Some time ago I compared a 40 meter dipole against a 40 meter ground plane. During the day, the dipole ran rings around the ground plane on contacts within, say, 1000 miles. At night, beyond 1000 miles, the ground plane was much the better antenna."

"I had much the same experience on 80 meters when I was running a sked from San Francisco to Los Angeles", I replied. "The 80 meter ground plane was worthless on this hop, but a low dipole—about 25 feet off the ground was just perfect. The distance was about 420 miles."

I took a small pamphlet off the desk and tossed it to my friend.

"Have you ever seen this?", I asked. "Its the *National Conest Journal* sponsored by the Southern California Contest Club. It costs four dollars a year in the USA. The editor is Pete Grillo, W6RTT (Box 3762, Glendale, CA 91201).

"Well this little publication has a lot of good feedback from contest operators on operating techniques, contest news and—of course—contest antennas. The January-February issue has a short article on quick and dirty contest antennas that makes very interesting reading. For example, there's a write-up of the 40 meter "droopy beam" thrown up by W6RRT for 40 meter work. Pete had a 15 over 20 meter stack, but nothing for 40 meters. So he put plastic plugs made of PVC tubing in the ends of the beam directors and reflectors (fig. 7) and spread a 40 meter wire beam over the two regular beams. He had a crank-up tower and could reach the tips of the beams from the ground, using an extension ladder. He strung the 40 meter wires over the existing beams, making a two element 40 meter beam that drooped over the aluminum beams. The lengths of PVC tubing separated the beams. And the wire elements were held in position with 3 ounce lead weights. How does that grab you?"

"Pretty clever", remarked Pendergast. "I see he used a quarter-wave matching transformer and a balun to match the 40 meter wire beam".

"That's right", I replied. "The feed point impedance of such a contraption probably is quite low."

"I wonder how it worked?", mused Pendergast as he sketched the "droopy beam" into his notebook.

"Have you ever heard the rock-crusher of Pete's on 40 meters?", I countered.

"No", replied my friend. "And I don't want to run across him in a pile-up". He gathered up his notebook as he prepared to leave.

"By the way", he remarked. "In your July column, the drawing of the single-wire fed antenna was all screwed up. Anybody who works from that picture will be in a heap of trouble".

"I know", I replied. "I got several hot letters about it. So here's the correct drawing (I hope), maybe it will be right this time (fig 8).

Station Operators *(from page 90)*

+ W3RRX, K4BEO, K4CFB, K4WVT. **W3FCI** + WA3ZAS. **WA3VQP** + W3CRE. WA3YGH + W3DQG. **W4BFB:** WA4FKY, WA4CJA, WA4APD, K4GHR, WA4VKW, Teresa. **W4JD** + WA4HHW. **W4KXV** + K4AW. WA4RVC + K4IIF. **W6BIP** + WA6DJI. **W6OAT** + WA6DIL. **W6UA** + W6UM. **WA6JUD** + K6LCC. **WA6NGG** + WA6FWJ. WB6HDH, K6PJY. **W7FR:** W7PHO, WA7TLK, WA7UQG. **W7FU** + W7RX, W7APN, VE7ZZ/W7. **W8HBK** + W8KPL, K8LJR. **WA8ZDF** + W8QXQ, WB8AKU, WB8AKW, K8EHU, K8RMK, WA8RWU, WB8RIJ. **W0HZ** + W0AW, W0YCR, K0IEA, W0HP, WA0YLN, WB0ANT, W0IR, W0NAR. **WA0CPX** + WA0ONL, WB0DGA, K0HUD, W0GKE, W0SMV. **YV1AJQ:** Branislav, Rastislav, Mravik, Sifel, Severini. **YU1GMN:** YU1PEF, YU1QEF, YU1QEH, YU4RS-606. **YU2CBM:** Zdeslac, Bozenko, Goran. **YU2CBV:** YU2RPY, YU2RTG, Zeljan, Miro. **YU4EJC:** YU4RS-3552. YU4RS-3456, YU4RS-3554, YU4RS-3555. **YU4JLM:** YU4RS-2105, YU4RS-2121, YU4RS-2135, **YV5RT:** YV5FKW, YV5FEZ, YV6OV, YV3BJ, YV5AV, YV1TO, YV5AGS, YV5FFH, YV5AW. **ZD8W:** WA4TLB, KP4EAJ, KP4EKI. **4J6A:** UW3HV, UW6FZ, UA6HZ. **5WIAZ:** WB6OOL, WB6DSV, W6RGG. **9D5A:** K6KM, W7CFJ. **9K2EP:** SM0OS, SM2CXV. **9Y4A:** W2DXL, W2AX, W2ER, W2GC, W2GGE, K2LE.

QRP *(from page 66)*

3040 kHz, 7040 kHz, 14065 kHz, 21040 kHz, 28040 kHz; s.s.b.—3990 kHz, 7290 kHz, 14340 kHz. When using these frequencies, call "CQ QRP" periodically. If everyone listens, no one will make a QSO! Quite a few QRPp'rs have become frustrated about these calling frequencies since they never find anyone there. My own experience is that I've generally worked a lot of QRPp guys on these spots—very often as a result of calling "CQ QRP." So, keep at it over a period of time and you should drag

(Continued on page 94)

a monthly feature by

WILLIAM I. ORR, W6SAI

Antennas

Design, construction, fact, and even some fiction

Pendergast carefully folded the letter and placed it in the drawer of his operating desk. He sighed heavily and said, "I wish I was rich instead of good looking."

"What's wrong?", I inquired. "Did you get beaten-out in a pile-up?"

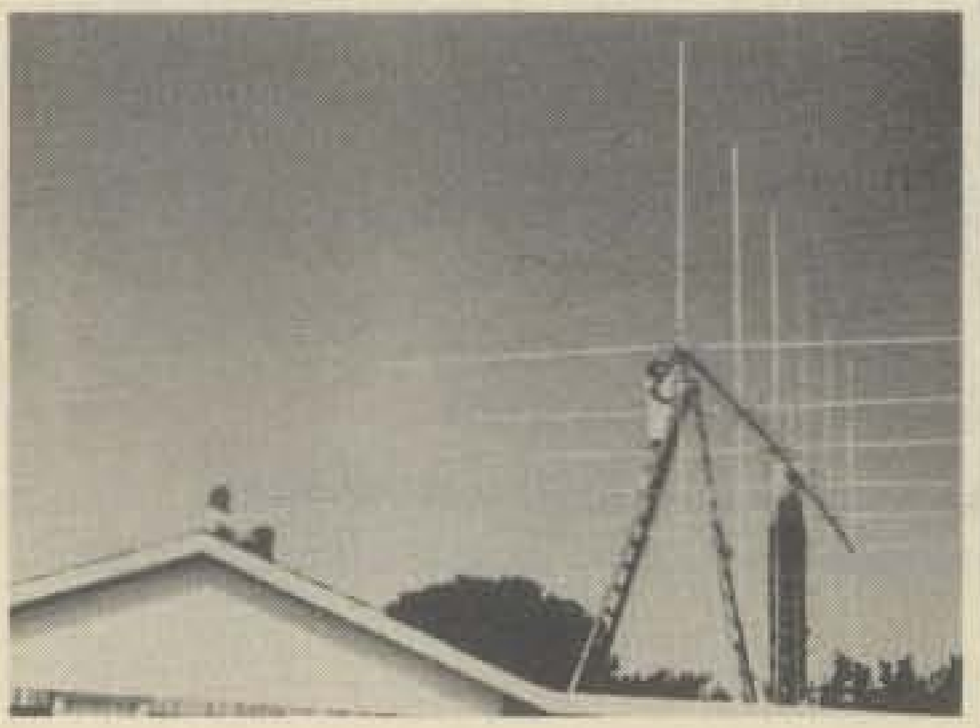


Fig. 1—The six element, three-band Quad of W5VGE. A 52 foot boom is used and the array is mounted on a 72 foot, heavy-duty crank-up tower. WB5NJK at left supervises antenna adjustments, which are made from the top of a step ladder on the roof.

"No," he replied. "But I just got a letter from Don, K5DUT, that just spoiled my whole day. To make matters worse, he sent me a bunch of pictures that are positively demoralizing."

"I didn't know you could send obscene material through the mail. There are laws . . ."

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Fig. 2—The six element Quad of W5MOK is mounted on a 50 foot boom. The boom is mounted in a sleeve that permits the antenna to rotate along its axis for ease of maintenance and tuning. Antennas are fed with separate coaxial lines.

My friend tossed a small stack of photographs across the desk.

"Obscene, indeed. That's a good word for it. These are pictures of some of the big antennas in Cow Town—Fort Worth, Texas to you.

"About three years ago Don put up a five element Quad on a 50 foot boom. It worked so well he went to a six element job."

Pendergast opened the desk drawer and removed the letter. "Listen to this," he said. He put on his glasses and started reading.

"Don's Quad has six elements on a 50 foot boom. The boom is three inches outside diameter at the center, with a quarter-inch wall. The tip sections are two inches outside diameter, with an eighth-inch wall. The material is T6 aluminum alloy and the boom has a single top-guy to remove any sag. The spreaders are fiberglass, spiders are home-made from aluminum angle and muffler clamps. There are six elements on 10, 15 and 20 meters.

"K5DUT feeds the array with RG-8/U coaxial line up the tower to a relay that feeds each driven element separately. The antenna is at the 80 foot level atop a Rohn type 55 tower. To top it off, Don has a custom-designed, home-built elevator that allows the whole antenna and rotor mast assembly to ride up and down the side of the tower at the flip of a switch!

"Don goes on to say that this Monster Quad has been up for almost three years and has survived winds up to 70 miles per hour with no broken wires. He uses "motor-rewinding" copper wire, size 12 or 14 that has been prestretched before use. The spreaders are Calcutta bamboo which is very strong and much better than regular bamboo. A prop-pitch motor is used to turn the Quad, as a heavy-duty amateur-style rotor won't stand up under the torque created by the antenna in a heavy wind."

Pendergast paused for breath and pushed a photograph under my nose.

"This is a shot of Luke, W5VGE, working on his Quad with WB5NJK supervising (fig. 1). The antenna is on a 72 foot heavy-duty crank-up tower. The array is composed of six elements on a 52 foot boom. The boom is only two inches in diameter, but is braced with aircraft cable at four points. This proved to be impractical as the boom broke last winter in the wind and ice. The W5VGE design, however, is very

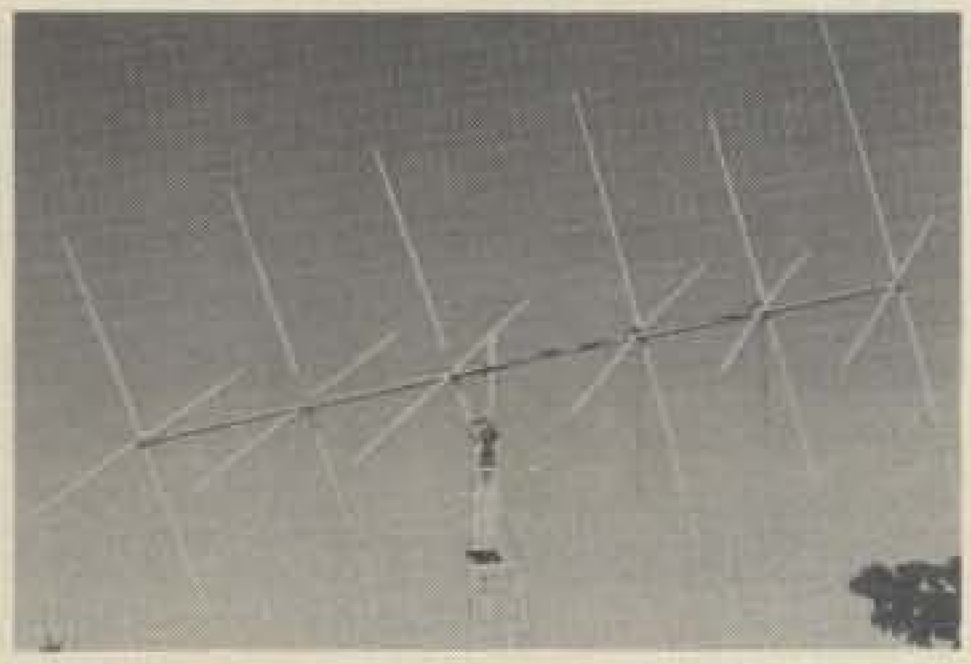

Fig. 3—The Monster Quad at WB5NJK. The boom is 48 feet long. Separate frame is used for 10 and 15 meter driven elements (at right). The antenna is 55 feet in the air.

interesting as it uses *two* reflectors, a driven element and three directors. The front-to-back ratio is very good—over 40 decibels, and the front-to-side ratio is equally good—over 60 decibels. Unlike the K5DUT Quad (which is square), this one has a diamond configuration for ease of assembly. Element spacing, from back to front, is 11 feet, 10 feet, 10 feet, 10 feet and 11½ feet."

I looked at the photograph. "The idea of using two reflectors is very refreshing," I replied. "A little while ago I spoke to Clarence Moore, W9LZX, the inventor of the Quad. He's tried mul-

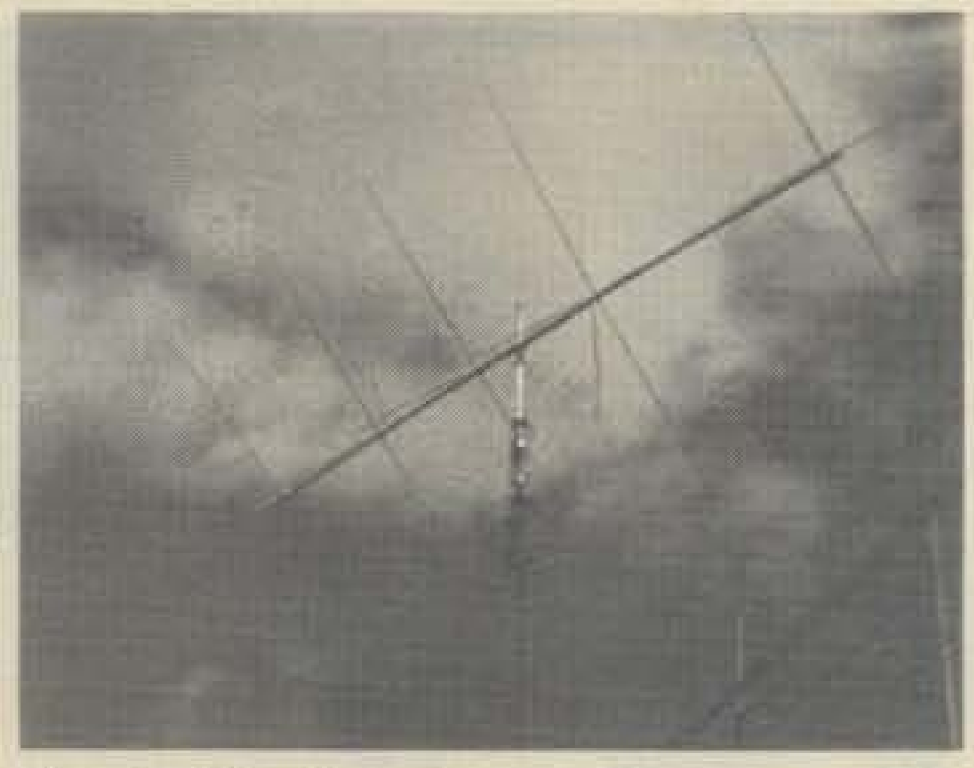

Fig. 4—The five element Quad of K5YYH. The boom is 46 feet long and separate feedlines are used. The antenna is 65 feet in the air.

tiple reflectors and spoke very highly of them. Really improves the front-to-back ratio."

Pendergast passed me another picture. "Here's the antenna of Bob, W5-MOK (fig. 2). Six elements on a 50 foot boom. The boom is three inch diameter irrigation tubing reinforced by a 20 foot slip-in section of T6 aluminum tubing having an 0.09" wall thickness. The boom is guyed af four points along the length. The boom itself is mounted inside a sleeve that allows the boom to rotate about its axis for maintenance and tuning. Spreaders are Calcutta bamboo. Spiders are aluminum angle and muffler clamps. The antenna is installed on a Rohn fold-over tower that has been reinforced and well guyed. Antenna height is 82 feet. The antennas are fed with separate RG-8/U lines that run up the tower."

"I like the idea of the boom rotating in the collar," I said. "When you get a monster like this up in the air, it is very unhandy to work on."

"Don't go away," said my friend. "I have more." He handed me another picture. "This is the Monster Quad at WB5NJK (fig. 3). Pierce has five elements on 20 meters and six elements on 15 and 10 meters. The boom is 48 feet long, and is made of three inch outside diameter T6 aluminum pipe with a 0.09" wall. The boom is guyed at two points each side of center. Separate X-frames are used for the 10 and 15 meter driven elements and separate RG-8/U lines run to each element."

"What about the element spacing?", I inquired.

Pendergast looked at the information on the back of the photograph.

"According to this, spacing for the 20 meter elements is 14 feet, 12 feet, 11 feet and 11 feet. And for 15 and 10 meters, spacing is 7 feet, 7 feet, 12 feet, 11 feet and 11 feet. That's from back to front."

Pendergast looked again at the letter from K5OUT. "W5MOK's antenna is at the 55 foot level on a Rohn type 25 tower that is rigged to lay over at the base for maintenance. Calcutta bamboo is used for the arms."

"I wish I knew what Calcutta bamboo is," I said to myself.

"Ready for the next one?", asked Pendergast. "Here's the Quad of K5-YYH, Steve (fig. 4). This has five elements on a 46 foot boom. The boom is three inch diameter irrigation tubing guyed at four points along its length. Much the same construction as the other Quads, and separate feedlines for each driven element with a remote relay on the antenna to switch to main feedline. The antenna is at 65 feet on a Rohn type 25G fold-over tower that has been reinforced."

"Well, the amateurs in Cow Town certainly know their business," I said. "I've heard and worked these fellows and they are *very* loud."

"Here's a final note from Don," remarked Pendergast as he carefully gathered up the pictures. "Don says that all Quads have been installed in such a fashion that allows access to the elements from the ground, from the roof or from a ladder (fig. 5). This is a necessity for an antenna of this size if you want to do any tuning or adjustment. He also says that all of the hard work that went into building these antennas has really paid off in performance and that the Quads have consistently beaten out large monoband Yagis that were up to 125 feet in the air. They seem to do better on both long and short skip that an Yagi, even if the Yagi has the edge in height! He can't explain the superior performance as compared to a Yagi, but all of the owners of these "Six-gun Quads" are convinced that they will beat out anything on the air!"

"They certainly do things in a big way in Texas, don't they?", I replied.

"Remember the Alamo," said Pendergast.

"Let's come back down to earth and look at some simpler antennas. The July, 1977 issue of *Radio Communication*, the great publication of the Radio Society of Great Britain, has a good article by GI3XZM on loop antennas for the 80 meter band. First of all, a summary of the radiation resistance of various loop antennas is given from a computer calculation. Using this data, GI3XZM has estimated that typical Quad loop radiation resistances are about one ohm for a 0.375 wavelength loop, 3.5 ohms for a half-wave loop, 12 ohms for a 0.75 wavelength loop and 150 ohms for a full wavelength loop. This tells us some very interesting information about small loop antennas. A regular Quad loop, thus, has a radiation resistance of about 150 ohms since it is a full wavelength in circumference. A 40 meter loop, therefore, can be operated on 80 meters provided the point opposite the feed point is opened. Bandwidth will be quite narrow on 80 meters, but antenna losses will still be quite low, even if the loop is made out of wire. A smaller loop than this clearly calls for low-loss construction because of the low radiation resistance and high circulating current.

"Some of the experimental loops tried by GI3XZM are shown in the drawing (fig. 6). Antenna (a) has 140 feet of wire arranged in a triangle. It is voltage-fed at the center of the bottom

(Continued on page 90)

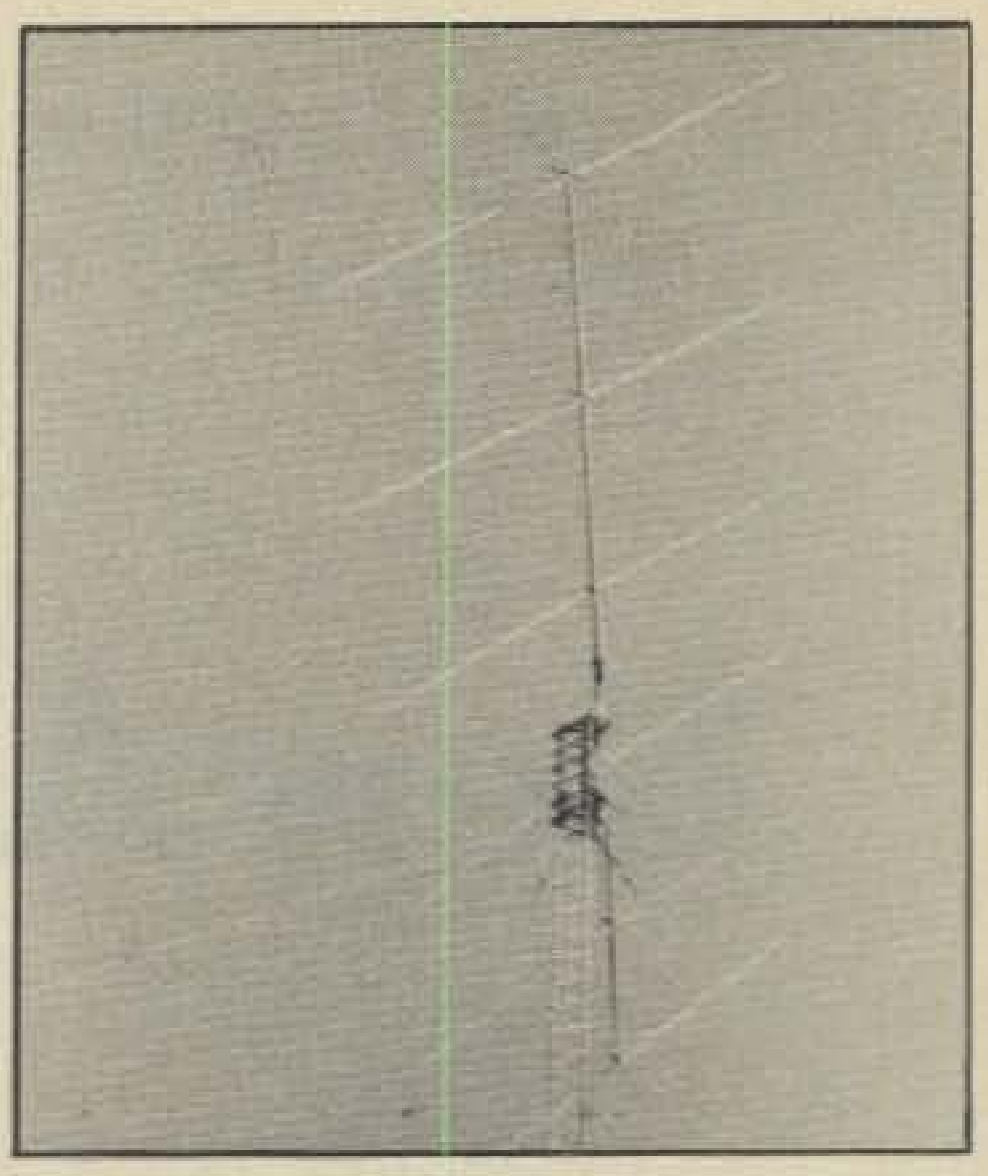

Fig. 5—The six element Quad of K5DUT that started the whole thing. The boom is 50 feet long and antenna is 80 feet in the air. The relay at antenna switches feedline to individual driven element.

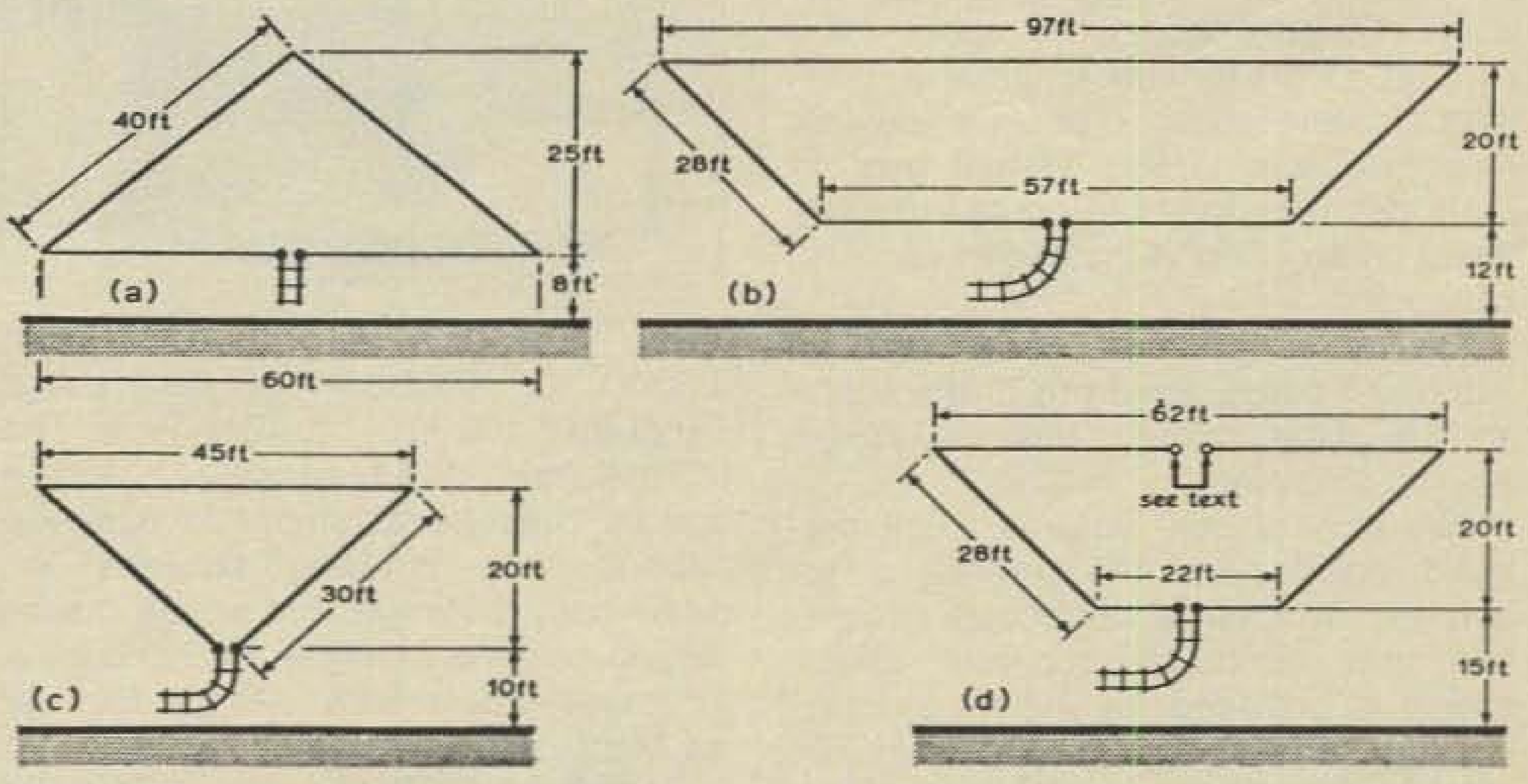

Fig. 6—The experimental loop antennas at GI3XZM. At (a) is half-wave loop for 3.5 MHz, fed with open wire line and antenna tuner. Shown in (b) is a 210 foot loop to provide ¾ wavelength on 80 meters. Open wire feedline and antenna tuner are used. At (c) is 105 foot loop. Antenna (d) provides operation of 80, 40 and 15 meters with link shorted and on 20 and 10 meters with link open. Drawing courtesy of "Radio Communication" magazine.

Antennas *(from page 61)*

wire with an open-wire line about 15 feet long and an antenna tuning unit.

"Antenna (b) is a "squashed loop" with 210 feet of wire in it. This is a ¾ wave loop for 3.5 MHz fed with an open-wire line about 80 feet long, with an antenna tuner at the shack.

"Figure 6 (c) shows a 105 foot loop for 3.5 MHz. This works out to be about ⅜ wavelength of wire. Tuning is very sharp as the radiation resistance is very low. The loop is fed with an open-wire line and a tuning unit. This is about the minimum size loop that will work on 80 meters without appreciable loss. Use large size wire to keep the resistance low. And, finally, illustration (d) shows a 140 foot loop for 80 meters. It is also suitable for 7 MHz and 21 MHz as-is and also works on 14 MHz and 28 MHz with the top connection opened. This looks like a very inexpensive multiband antenna. It is fed with a two-wire open line and an antenna tuner at the shack."

"Not bad," agreed Pendergast, sketching the loops in his notebook. "I like the last design. Two supports about 35 to 40 feet high will do the job."

"GI3XZM points out that noncircular loops (triangles, squares, etc.) enclose less area than a circular loop of the same circumference and so further reduce the radiation resistance. Nevertheless his experience indicates that in practice such systems, when fed with open-wire resonant feeders and an antenna tuning unit, can achieve better efficiency than some of the "bent" dipoles and "squashed" Marconi-type systems fed against a ground connection of doubtful efficiency. And I agree with that statement."

Pendergast smiled. "I've always had a lot of luck with full size loop antennas. They are very forgiving. About the only fault I can find with my 80 meter Quad loop is that the signal pickup is so great—with all that wire in the air—that I have overload problems with some of the local signals."

I sprang from my chair and picked up a bound volume of magazines. "That reminds me," I remarked. "Here's something that will interest you. Again, it appeared in the R.S.G.B. magazine. Amazing, the amount of good stuff they have each issue. Well, it is an a.g.c.-controlled r.f. attenuator (fig. 7). The attenuator goes in series with the coaxial line to the receiver and the gain of the attenuator is set by the a.g.c. level of the receiver. Basically, it is a ferrite transformer, whose coupling is determined by a control winding. Transformer response is 1.8 MHz to 30 MHz, so bandwidth is no problem. Coupling between primary and secondary is determined by the bias voltage applied to the control winding. The threshold of action is set by a 10K bias potentiometer and as much as 22 dB of attenuation is afforded by the 40673 JFET. Bias voltage for the gates of the JFET ranges from +2 to +5 volts.

"Insertion loss of the r.f. attenuator runs from 4 dB at 1.8 MHz to 2 dB at 30 MHz. Maximum attenuation runs from 20 dB to 24 dB over the same frequency range. As it stands, the device works from a positive a.g.c. line, but can be modified to work from a negative line. The ferrite bead is described as "tiny" in the original article and the British part number is given (FX-1115), but I imagine any equivalent h.f. ferrite core or bead would work. Note that the control winding is done in a figure-8 configuration."

"Pretty clever," said my friend. "I'll have to haywire that design up and try it out. It should help a lot when some of the local powerhouses come on the air."

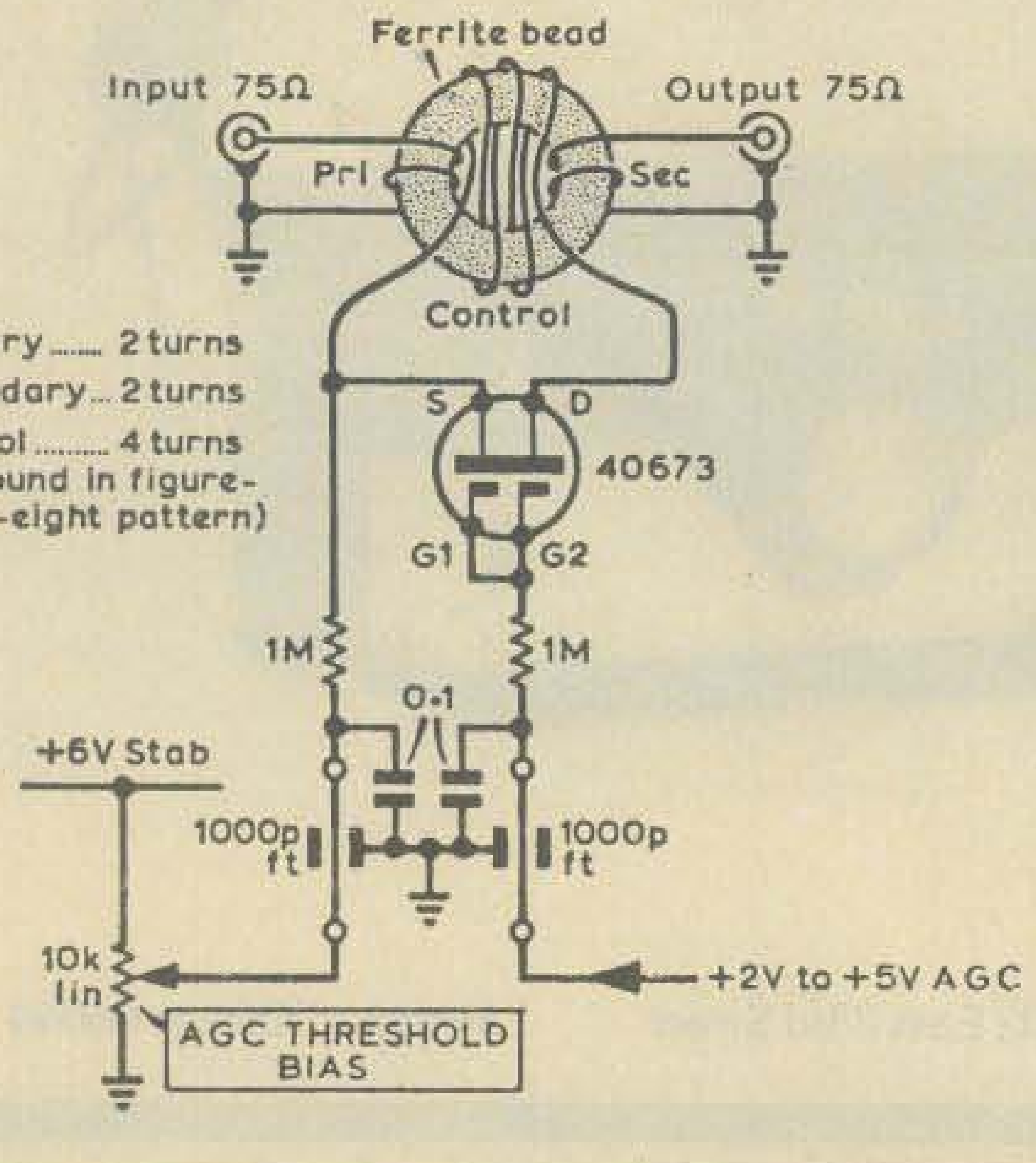

Fig. 7—The automatic "aerial attenuator" of G4AIL provides direct control of input signal by a.g.c. system of the receiver. See text for details. Drawing courtesy of "Radio Communication" magazine.

I started toward the door of Pendergast's shack. "Before I push off, I'd like to read you something from the April, 1926 issue of the *IRE Proceedings.* It is from "The Polarization of Radio Waves," by Greenleaf W. Pickard. He's speaking about high frequency trans-oceanic reception. This is what he says: 'My findings at Seabrook may be summed up as follows: Under night conditions for frequencies above three megacycles, and for distances over 50 kilometers, the electric field at the receiving point is predominantly horizontal. The ratio of the horizontal to the vertical electrical component is determined solely by the transmission frequency and the distance, and is independent of both the direction of transmission and whether the wave left the transmitter horizontally or vertically polarized.

" 'For frequencies above three megacycles, there is a real advantage in horizontal reception. Not only is the electric field and hence the signal stronger, but the signal/stray ratio is markedly improved, because the horizontal component of the static does not increase so rapidly with frequency as does that of the signal.' "

Pendergast replied defensively, "Well, I can still work a lot of DX with my ground plane antenna!"

"Yes, but think of all the good DX you really can't hear!", I replied, as I went out the door.

* * *

Radio Communication is the publication of the Radio Society of Great Britain. Inquiries as to subscriptions or membership in the society should be directed to: Radio Communication, 35 Doughty Street, London WC1N 2AE, England. Design information on multi-element Quad beams and Quad loops can be found in *All About Cubical Quad Antennas*, published by Radio Publications, Inc., Box 149, Wilton, CT 06897. Price: $4.75 plus 35¢ postage and handling.

73, Bill, W6SAI

CQ Reviews: The MFJ Antenna Tuner *(from page 45)*

superior to a random wire, provided you can properly fasten the ends of the dipole up in the air. With this tuner you can use a folded dipole for multi-band operation without the usual stray r.f. problems resulting from the use of a random wire.

The price of the Super Tuner is $69.95 plus $2.00 shipping. If you are not satisfied you may return the unit for a refund less shipping, within thirty days. For more information contact MFJ Enterprises, P.O. Box 494, Mississippi State, Mississippi 39762 or call them toll free at 800-647-8660. ■

a monthly feature by

WILLIAM I. ORR, W6SAI

Antennas

Design, construction, fact, and even some fiction

"Well, by golly, 1977 is drawing to a close," said Pendergast. "Here I am, a year older, and not a penny richer." He closed his logbook and pushed aside a stack of QSL cards that he was filling out.

"What do you think was the DX highlight for this year?" I asked.

"That's easy," replied my friend. "The outstanding DX highlight was the slow increase in the sunspot cycle during 1977 and the start of the new sunspot cycle 21. Already the bands are picking up. Fifteen meters is jumping and have you listened on 10 meters? That band is finally beginning to show signs of life."

"Do you want to make a guess as to when this new sunspot cycle will peak and what that peak will be?", I asked.

"Certainly," replied Pendergast. "My motto is *often in error, never in doubt.* Based on that presumption, I'll bet the cycle peaks during the fall of 1982 and the peak numbers will be between 55 and 75." He scribbled the numbers on a piece of paper and handed it to me.

"We'll just have to wait and see what George Jacobs, W3ASK, has to say about this in his column," I said.

"Don't forget that George gets his propagation data from me," laughed Pendergast, as he dismissed the subject with an airy wave of his hand. "Suppose we stop second-guessing and talk about antennas. They provide the results, regardless of the sunspot number!"

"O.K.," I said briskly. "Let's start out with our friends 'down under,' specifically the magazine *Amateur Radio,* which is the publication of the Wireless Institute of Australia. There's a nifty article by VK5TT and VK3MO concerning the effect of the ground on the directional pattern of a 20 meter Yagi beam antenna.

"The problem was to determine the actual directional pattern of VK3MO's antenna which consisted of stacked 20 meter, three element Yagis. The top Yagi was at 100 feet.

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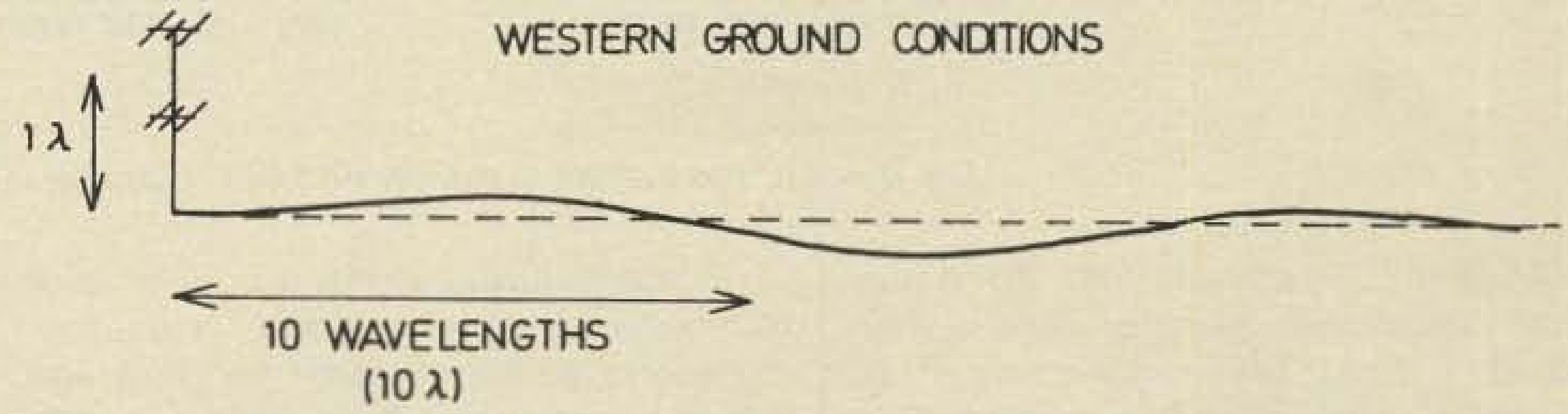

Fig. 1—Ground conditions at VK3MO to the west.

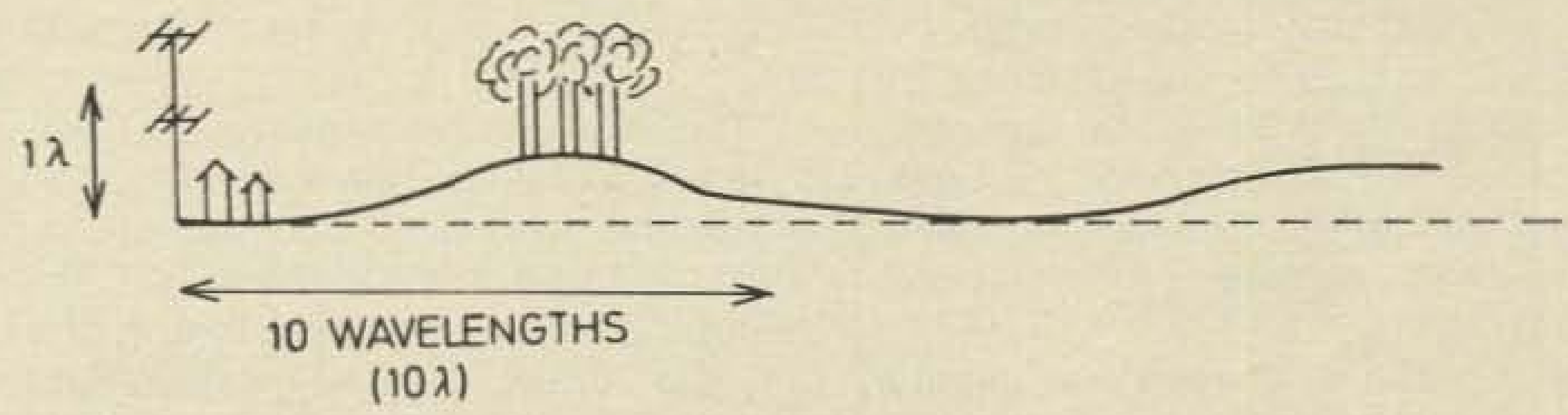

Fig. 2—Ground conditions to the south.

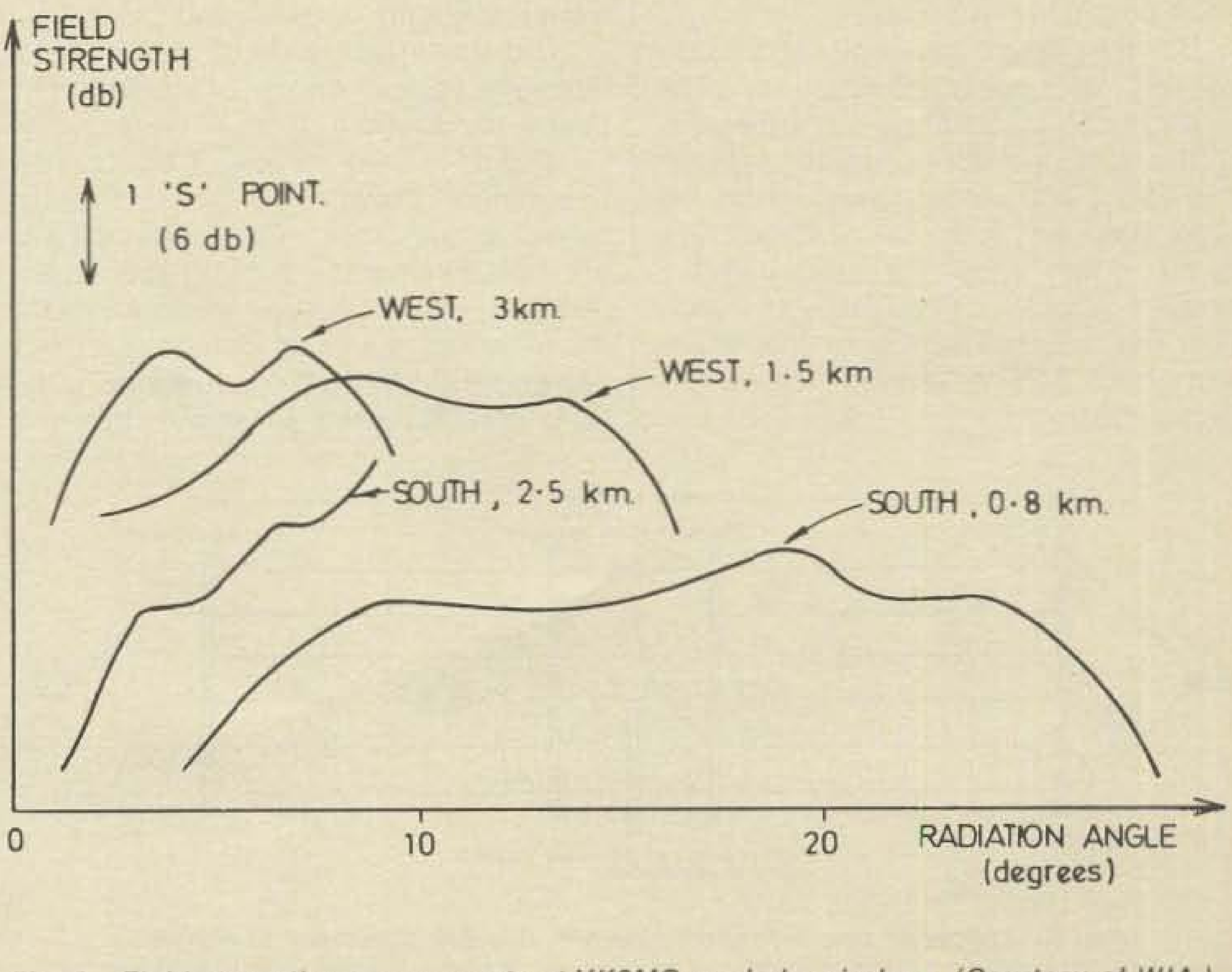

Fig. 3—Field strength measurements at VK3MO made by airplane. (Courtesy of WIA.)

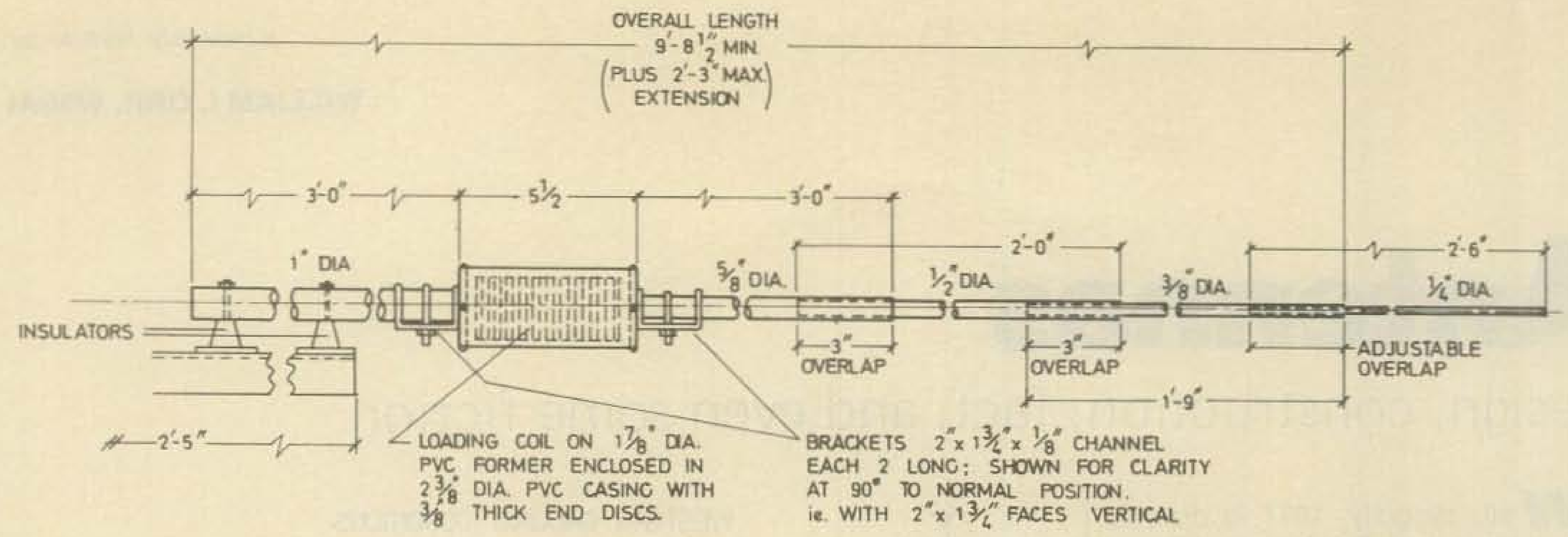

Fig. 4—Half the loaded dipole at VK3AZX. (Courtesy of WIA.)

"A TS-520 receiver with an accurately calibrated S-meter was taken aboard a light plane which had an antenna tied between the wheels. The plane flew at various heights and headings relative to the Yagi antenna and signal strength readings were recorded. After landing, the directional pattern of the antenna was calculated using the S-meter readings and by making allowances for the distance of each measurement from the antenna. For purposes of calculation, it was assumed that the emitted radiation was from midway between the stacked antennas.

"The directions chosen for inquiry were to the west and south of the antenna (figures 1 and 2). The land was clear to the west for at least 10 wavelengths. The soil in this direction was volcanic in nature, having reasonably good conductivity.

"To the south, the soil was sedimentary of poorer conductivity. The ground rose at an angle of 4 degrees to the antenna for a short distance and about 150 meters away, atop the slight rise, was a grove of trees. Also to the south were the house and a garage, about 0.5 wavelength away from the tower. The top of the house was about 0.25 wavelength below the lowest beam."

"It looks like a pretty good location to me—in both directions," remarked my friend as he studied the drawings. "What were the results of the tests?"

"Well, the results were very interesting," I replied. "First of all the signal to the west was far stronger than the signal to the south. There was a 12 dB signal advantage to the west, and radiation was at a lower "angle of fire."

"The signal advantage to the west is very interesting, but it is difficult to isolate the individual contributions of house, hill and trees to the south. The treetops are level with the top antenna. But the trees are 10 wavelengths (nearly 800 feet) away from the antenna. The hill subtends an angle of four degrees to the antenna, so radiation below this angle is effectively blocked. Even so, the difference in signal strength is profound."

"Did the article have a plot of field strength versus angle of radiation?" asked my friend.

"It did," I said. "Look at fig. 3. The two higher curves are measurements made to the west. The lower curves are measurements made to the south. As you can observe, measurements made to the south at distances of 0.8 kM and 2.5 kM from the antenna were considerably down in signal strength compared to the western measurements."

"It's a puzzlement," admitted Pendergast as he studied the drawings. "I can see that the hill to the south could cut off *some* low angle radiation and the presence of the house *may* have some slight affect. But how do you account for the tremendous difference in signal strength between the two directions?"

"My guess would be soil conductivity," I replied. "I just hope that VK5-TT and VK3MO have the opportunity to make further measurements to try and isolate the various factors. After all, the question of what makes one location better than another one is vital and of interest to all radio amateurs!"

"Anything else from Australia?" asked Pendergast as he copied the antenna data in his notebook, pushing the pile of QSL cards to one side with his elbow.

"Yes, indeed. VK3AZX has a great article in *Amateur Radio* concerning a short 40 meter loaded dipole (fig. 4). The drawing shows half the dipole. Overall length is about 22 feet. Since the antenna is quite short, the bandwidth is rather narrow, being about 1.2-to-1 over 15 kHz. That gives an operational range of about 50 kHz before the s.w.r. tends to get out of hand.

"VK3AZX has compared the compact dipole against an inverted-V antenna and a vertical, loaded whip and reports that the dipole does the better job and has a lower noise level by one to three S-units.

"As far as construction goes, the drawing tells the story. Each half-element tapers from one inch diameter at the butt end to a quarter-inch diameter at the tip. The tip section is long enough so that each tip can be varied in length by 18 inches. That's a good

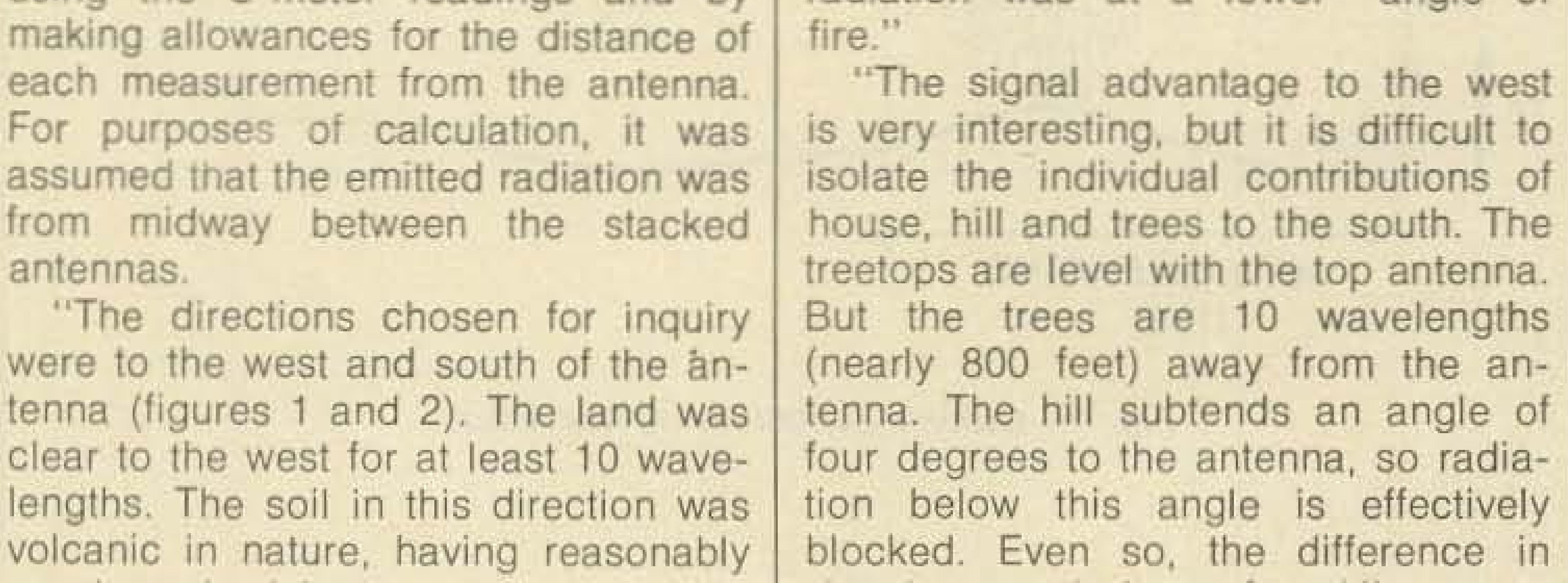

Fig. 5—Layout of the multiband dipole of G3KSK. (Courtesy of RSGB.)

idea because element length depends a lot upon element taper, and the taper is quite pronounced in this design.

"The element loading coils are wound on 1⅞" outside diameter PVC (polyvinylchloride) pipe commonly used for water lines. The coil form is 4½ inches long. End discs are made of the same material.

The coil casing is made of a 2⅜ inch length of PVC tubing, 5½ inches long.

"The coil is wound of fifteen feet of copper wire (size unspecified, unfortunately). It is closewound under tension and then spaced out by winding a thin cord between the turns. This provides a spacewound coil slightly less than 4½ inches long.

"Holes are drilled in the end of discs to take the coil form and the end discs are bolted to short sections of aluminum channel drilled to pass the aluminum elements on the parallel sides. A U-bolt through the channel clamps the coil firmly to the element sections. The bolts that hold the channel section also make connection to the coil winding so that when the coil is mounted to the element sections, a good electrical contact is made.

"The coil by itself is self-resonant at about 145 MHz. When it is complete, the casing is slid over the assembly and held in place with PVC cement.

"Lengths and overlaps of the element sections are shown in the drawing. When each assembly is complete, you have two 40 meter, quarter-wave whips, each about 11 feet long. You can test each one separately as a loaded vertical antenna working against ground plane radials. If you do this, adjust the tip sections so each one is resonant at the same frequency in the 40 meter band. However, you can mount the whips to the standoff insulators and the aluminum channel support and test the unit as a dipole."

"How about the feedpoint impedance," asked Pendergast, drawing furiously in his notebook. "Isn't it rather low?"

"Yes," I replied. "It runs close to 12 ohms. The easiest and best way to feed the antenna is to use a four-to-one balun reverse-connected. That is, to provide a stepdown ratio of four-to-one from the line to the antenna.

"The antenna can be mounted on a step ladder for preliminary test. It should be adjusted for lowest s.w.r. about 20 kHz higher in frequency than desired, because the resonant frequency will probably drop as the antenna is raised to its full height."

"That looks pretty nice," remarked my friend. "My compliments to VK3-AZX for an interesting little antenna."

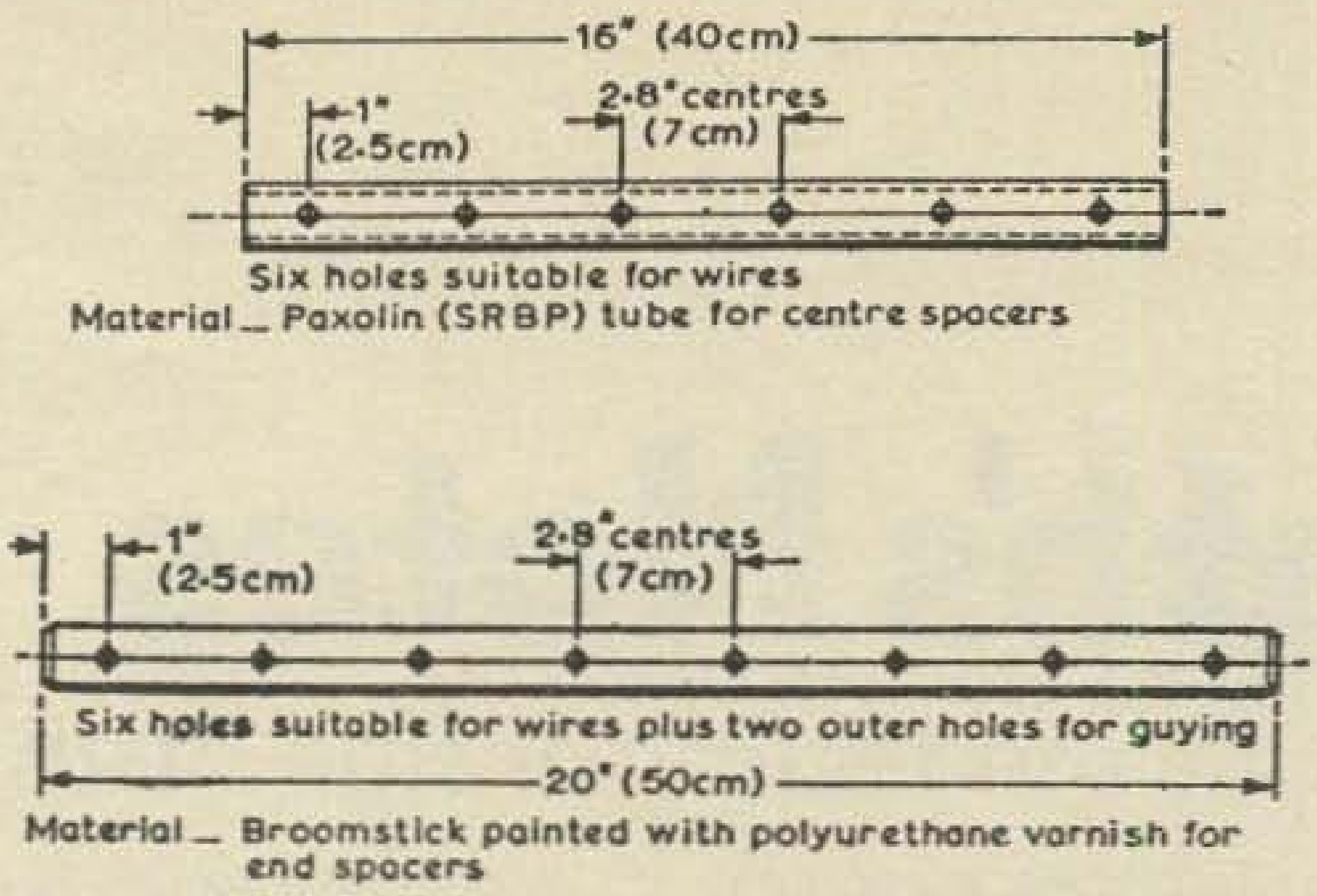

Fig. 6—Spacers for the multiband dipole.

"One more item before you run off to do your Christmas shopping. Here's a sketch of a very interesting compact multiband dipole for operation on 80, 40, 20, 15 and 10 meters (fig. 5). It is designed by G3KSK and is featured in *Radio Communication,* the magazine of the Radio Society of Great Britain. Basically, the arrangement consists of four dipoles fed in parallel and doubled back on themselves. The 40 meter dipole is used for 15 meters. G3KSK says the "construction is interesting and frustrating" as it is desirable to divide the strain equally between each of six wires. He left wire loops at the ends of the sections to make last minute adjustments.

"The assembly is 41 feet long and 20 inches wide. The spreaders are made out of wood and "Paxolin," which is something like PVC tubing. A coaxial transmission line 43 foot long was chosen because it provided a transformer action on 80 meters that boosted the low radiation resistance of the antenna to a value more suitable for the conventional pi-network circuit. It has no effect on the other bands.

"The spacers are shown in fig. 6 and a summary of dimensions is also given (Table 1)."

"It's not a bad idea," admitted Pendergast. "I think the only problem would be adjusting the tension on the various wires so that the assembly looks ship-shape when it is up in the air."

"That's right," I replied. "Why don't you build one up and try it out in your spare time? Meanwhile, you might as well read this note I just received from Dave, W7TO. He took the half-loop antenna described in June *CQ* and modified it for multiband operation (fig. 7). The vertical sections are 33 feet long and the horizontal section is 66 feet long. Dave placed a ground screen under the antenna tuning unit and laid out a number of 70 foot radials. He's had a lot of luck with it on the high frequency bands, including a WAS on 160 meters. He says it works very well on 80, 40 and 20 meters. He's also had contacts on 10 and 15 with it, but band conditions have been so poor there's no way to evaluate operation on those bands. And he says it works much better than an inverted-L antenna that he used before."

Pendergast said, "Some of the simple antennas work very well and are the answer when it is impossible to put up a more imposing antenna array."

Band (m)	$\lambda/4$ (ft)	$\lambda/4$ (m)
80	66	20
40 and 15	33	10
20	16-5	5
10	8-25	2-5

Table I—Values of $\lambda/4$ for the five bands. Note that some adjustment of length may be necessary on 80 and 40 meters due to the effect of bending back on resonance.

"Most amateurs *don't* have huge beams on high towers, contrary to what it sounds like in a DX pile-up," I admitted. "My correspondence indicates there's a great interest in simple antennas."

Pendergast sighed and reached for the pile of QSL cards. He opened his log book and started to fill out the cards. As he worked, he said, "What is your prognostication for 1978 as far as antennas go?"

(Continued on page 112)

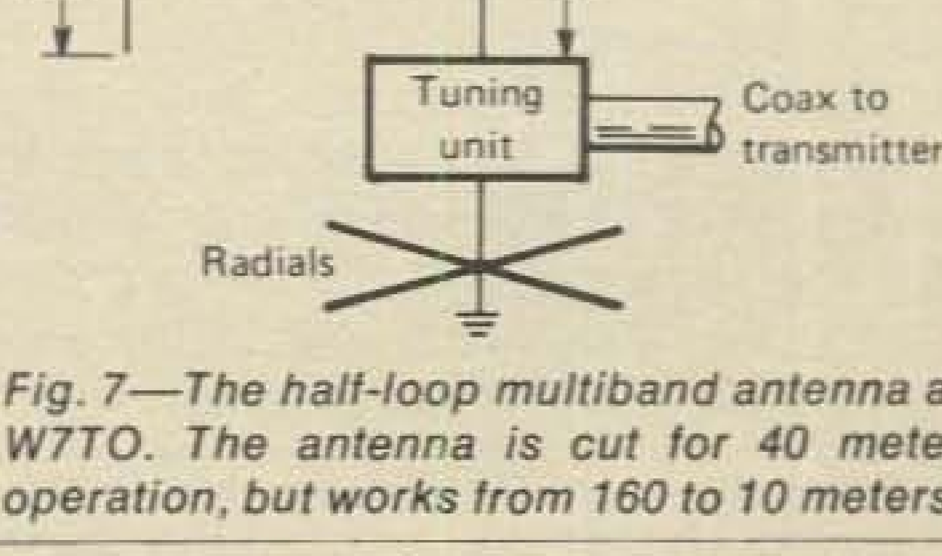

Fig. 7—The half-loop multiband antenna at W7TO. The antenna is cut for 40 meter operation, but works from 160 to 10 meters.

In Focus *(from page 54)*

the U.S. Meantime, several hundred Model 400 scan converters are in use by slow scanners on the amateur bands. At this writing, no model changes are contemplated.

Final-Final

Please keep the pictures and letters coming my way, your friends want to see what you are doing! Next month there will be an interesting review of Cop Macdonald's early efforts with pictures and data from his original prize-winning paper describing SSTV! Best regards, 73, Bill, W2DD

QRP *(from page 92)*

marily by the C3-C4 voltage divider and the C2 coupling capacitor. An oscillator is basically a self-excited amplifier, and C3-C4 provide the feedback required to sustain oscillation at some given operating level. Theoretically, such a stage should increase its gain indefinitely, but limitations of the transistor itself impede this increase. The ratio of C3-C4 can be varied to control the gain and operating level of the oscillator. However, operating the transistor at its limits is undesirable in a v.f.o. circuit, as it can result in signal impurities and instability. D1 serves the purpose of limiting Q1 gain once the optimum C3-C4 ratio has been found experimentally. Without D1, Q1 will operate at maximum gain and considerably larger r.f. current will flow across the gate-source diode than without it. In this case, the bias which limits stage gain would have to be developed across the FET gate-source diode, with a resulting increase in harmonics as well as increased loading of the frequency determining L1/$Cl_{a\text{-}d}$ circuit. A degradation of stability would be the likely result, although not inevitable. If conditions are optimum, an unclipped circuit will exhibit a steady rate of drift up and down a narrow bandwidth indefinitely, as well as intermittent jumps as the internally developed bias moves through thresholds. Such drift makes even short QSO's difficult. With D1 in the circuit, Q1 gain is limited to a stable level determined by the diode as it clips the positive excursions of the gate r.f. voltage swing. D1 wiill usually have a pronounced effect upon v.f.o. output, causing a considerable drop if the circuit is optimum. For example, in the units tested, a D1 vs. no-D1 comparison produced a 4.8 Vrms vs. 1.33 Vrms reading at the Q1 gate, and a 3.2 Vrms vs. 0.87 Vrms reading at the Q1 source. Output from Q3 likewise shows the D1 effect, with a 1.65 Vrms vs. 0.51 Vrms reading (into a 1000 ohm load).

Mechanical Stability

Mechanical stability is essential in any v.f.o. circuit. Since all r.f. bearing, frequency-sensitive leads are located only on the p.c. board in this circuit, most of the usual sources of mechanical instability are eliminated. However, several precautions can be taken. Oscillator circuit components should be placed firmly against the p.c. board before soldering, and leads should be as short as possible. Any vibration of the oscillator circuit components will produce microphonics as well as frequency jumps. Once the oscillator calibration is completed, RFC2, L1, and associated capacitors can be epoxied to the p.c. board. The slug in L1 can be stabilized by the rather simple expedient of pouring wax from a melted birthday candle (a soldering iron will do the melting job) into L1 so that the slug is completely encased in wax. Likewise, wax can be flowed over the L1 winding immediately after it is completed. In the units tested, these simple precautions produced oscillators which showed no effects of bumping, dropping, or knocking on the table.

Assembly

The p.c. board for the 7 MHz v.f.o. is shown in fig. 2. Double-sided p.c. board is used in order to facilitate construction of the enclosure shown in the photo. The underside foil is etched away from under the oscillator components. This is done to avert the problems that can be caused by the capacitances formed between circuit pads and underside foil. Board preparation can follow either procedure outlined in the first part of this article using addres labels or marking pen.

Once the board is completed, assembly can proceed with the mounting of Q1 components and the B+ regulation line across the top of the board. Oscillator operation can be verified by hooking up the B+ and reading the r.f. voltages at Q1. Initial frequency alignment can be attempted by listening for the v.f.o. signal in the station receiver while adjusting the L1 slug until it appears in the 40 meter band. Assembly of the remaining sections of the v.f.o. can then proceed. Finally, mount VR1 and the tuning potentiometer, and adjust L1 for the proper frequency setting.

In the past, this writer has put hours of hard work into constructing v.f.o. enclosures from aluminum stock. The result was always a box that only remotely resembled those professional jobs that can be had at Radio Shack. This time, an hour of experimentation produced a professional-quality enclosure with perfectly-straight edges—the trick is using double-sided p.c. board and soldering the thing together! See photo. A very stable enclosure indeed, with a very good heat insulation factor to boot!

Once the v.f.o. is assembled and aligned, output should measure around 0.5 Vrms into a 1000 ohm load. About 200 Hz jump in frequency should be the limit when going from open-to-short circuit across the output. The v.f.o. can be hooked up to the exciter discussed earlier, and key-down conditions should produce about 75 Hz "pull" at most on 20 meters. 200 Hz is acceptable.

Performance

The v.f.o.-exciter combination has performed excellently on the air in tests. The oscillator stabilizes in about ten minutes, and will remain within about 50 Hz of a crystal standard thereafter in a normally changing room temperature environment. Keying is sharp and clean. The only drawback was encountered when the vertical radiator developed difficulty in some undetermined contact which produced a large jump in impedance. This wind-caused jump produced a small "pull" on the oscillator frequency, and although QSO's were still completed, the jump was nonetheless annoying. Otherwise, the exciter-v.f.o. combination produces good QSO's to both coasts on both 40 and 20 meters, despite its 1 watt output. It would be wise to use a low-pass filter between the rig and antenna to avoid possible TVI complications in fringe areas. In short, the combo can be enjoyed while work proceeds on the final amplifier, which we will discuss in the next part of this article

Parts Sources

FB-43-801 "jumbo beads" from Amidon Associates. 12033 Otsego St., No. Hollywood, CA 91607.

Circuit Specialists Co., PO BOX 3047, Scottsdale, AZ 85257, is a good source for the following parts which may be difficult to find: L1 slug-tuned form, J. W. Miller #23A014-3 (green dot) ($1.21 ea.); VR1, R2502/MV2105 ($1.10); 1N914 D1 ($1.00/16); D2 6V or 9V zener (1N753/1N757) ($1.00/3); MPS6514 ($0.55 ea); MPF102 (0.50 ea).

Digi-Key Corp., PO BOX 677, Thief River Falls, MN 56701, for polystyrene capacitors, 0.15 ea. (order 460pf for C3, 91pf instead of 100pf, 280pf instead of 270pf—stock depleted).

Antennas *(from page 95)*

"That's easy," I replied. "The sunspot cycle is coming to life and there's going to be a lot more interest in 10 meter DX operation. A lot of amateurs

are going to put up 10 meter antennas as they are small, inexpensive and easy to get going. Some smart hams are going to take advantage of the cheap CB beam antennas and cut them down for 10 meter work. The 11 meter Yagis and Quads are not expensive and there's no problem getting most of them to work on 10 meters. So my prediction is: watch 10 meters during 1978. That's where the action is going to be!"

* * *

Note: For information on 10 meter beams of all kinds, the *Beam Antenna Handbook* ($4.95) and *All About Cubical Quad Antennas* ($4.75) are recommended. They can be ordered from Radio Publications, Inc., Box 149, Wilton, CT 06897. Include 50c per book with order for postage and handling.

Math's Notes *(from page 96)*

graph to the face of the cathode ray tube if one is not already provided. Transparent graph paper is available from some of the larger stationery stores, but in a pinch, a suitable face plate can be made from a thin sheet of plexiglass, ruled with a sharp scribe. As in the case of the signal generator, the binding posts of the vertical input should be replaced with BNC connectors when frequencies above 20-30 kHz are to be measured. Coaxial plugs should also be used on all probes. It is also advisable to regulate the scopes low voltage power supply in order to stabilize the horizontal sweep and the gain of the amplifiers. Since exceptionally high voltages are employed in oscilloscopes, always observe caution when working on one with the power on and/or the cabinet opened.

Preventative Maintenance Techniques and Intervals

The preventative maintenance techniques described in the following paragraphs are all used in one form or another by industry as well as the military. They are tried and proven and are used whenever the utmost in reliability and life are demanded in a piece of test equipment.

1. Obtain schematic diagrams for all pieces of test equipment on hand and mark on these diagrams, various important voltages or waveshapes encountered in normal operation. This will greatly simplify servicing when a device fails.

2. Correct all defects no matter how slight as soon as they are discovered. Waiting or putting off such corrections can cause major costly breakdowns later, even if the operation of the unit is not hampered at first.

3. Overheated resistors, leaking capacitors, or other components that do not seem to be in good condition should be replaced with ones of higher ratings and qualities even if the manufacturer did not use them originally. This, incidentally, is not an uncommon fault—especially with imported instruments.

4. All dust accumulated inside the equipment, especially in hard to get to recesses, between variable capacitor plates, and between contacts should be cleaned at regular intervals.

5. Screws, nuts, bolts and particularly set-screws in knobs and dials should be checked and tightened if necessary at least twice per year. All missing screws should of course be replaced. Remember 10 screws weren't put into your signal generator because the manufacturer had some extras lying around. They were put there to help keep the case r.f. tight.

6. The following, is a brief chart which summarizes the suggested maintenance schedule for all types of test equipment that undergo moderate use. If you use equipment very frequently, the time between performing various steps should of course be shortened.

	Daily	Weekly	Monthly	Semi-Annually	Annually
Exterior Inspection					
Interior Inspection					
General Screws, Set Screws, Nuts, Etc.					
Lubrication of Moving Parts					
Cleaning of Contacts and Terminals					
Calibration Spot-Checks					
Major Re-Calibration Complete					
Testing of Vacuum Tubes					
Complete Cleaning of Chassis, Tubes, Cabinet, Etc.					

When the above maintenance is performed on a piece of test equipment a surface gummed label should be affixed to the equipment giving the date performed and the date due for the next inspection period.

By observing the above, the experimenter will be able to get much more performance from his equipment. The frustration of having to repair the test equipment when making that "last measurement" before turning on a new piece of gear will be a thing of the past.

73, Irwin, WA2NDM

Novice *(from page 99)*

radio station for Novice use have covered station location, plus advantages and disadvantages of building and buying, new and used gear, solid state and tube equipment, low and high power, and transceivers versus transmitter and receiver combinations. This month's column also covered major factors to be considered regarding transmitters and next month's column does the same thing in regard to receivers.

The following stations were worked recently on the Novice bands: WA1-YAU, George Wellesley, Mass.; WB2-MAI, Bill — Alpine, N.J.; WB3GEN, Chris—Crofton, Md.; WD4AVJ, Karen — Largo, Fla.; WD5BQP, Katie — O'Donnell, Texas; WB6PTC, John — Los Angeles, Ca.; WB7PZR, Scotty—Boise, Idaho; WD8KXQ, Harry—Detroit, Michigan; WB9VCI, Paul—Monroeville, Ind.; and WDØCCK, Ed — Sioux City, Iowa.

Remember that no code sending test is administered at FCC offices. This portion of amateur licensing examinations was dropped in August 1977. Eliminating the code sending test made it possible for FCC examiners with no code capability to conduct code tests; they simply check the applicant's answers to the code comprehension receiving test questions. It is reasonable to assume that any applicant who passes a code receiving test will also be able to send code at least as fast as he can receive it. I have never known a student who could not send faster than he receives code. Unfortunately, everyone who can send code cannot send good code. Dropping the code sending test at the FCC offices may be a good move for the FCC but it will not benefit the quality of code sending heard on the amateur bands. Fortunately, the code sending test is still required as part of any FCC amateur radio licensing examination conducted by a volunteer examiner.

I would be glad to receive good definition black-and-white pictures of several Novices at their operating positions. If you send a picture, it might appear in a future Novice column. Please send an SASE if your photograph must be returned.

DX *(from page 103)*

at 0035. SU1CR was heard on 14244 at 0135 GMT. In addition, activity from the Sudan has been supplied by ST2-SA on 10 and 20 meter s.s.b., STØRK on 10 and 15 meter s.s.b. and STØRM on 20 meter c.w. DL9PL/ST has been heard on 14296 at 1615 GMT.

a monthly feature by

WILLIAM I. ORR, W6SAI

Antennas

Design, construction, fact, and even some fiction

Pendergast was hunched over his desk, examining a small drawing with great care. I came up behind him quietly and poked him in the ribs. He jumped as if he had been shot.

"Hello," he remarked as his cardio-vascular system returned to normal.

"You must have a guilty conscience," I said. "Why did you jump?"

"Who knows?" he asked cheerfully. "I was just looking at a Great Circle Chart centered on Australia (fig. 1). Interesting, isn't it?"

He didn't wait for me to reply, but continued on. "No wonder the VK's are such great DX-artists. Notice that they can work into Africa beaming west (270°), or east (90°). And it's almost a complete over-water path either way. And look at the path to the United States. Short path is 60° and long path is 240°. I remember when I lived on the east coast the VK's would come through the long path in the afternoon on 20 meters. And, believe it or not, I have worked Australia via the long path from California on 20 meters in the afternoon—right across the East Coast!

"South America doesn't look so easy. The VK's have to fire through the southern auroral zone on short path, and the long path is a *long* 12,000-miler which comes close to the northern auroral zone. But Antarctica should be duck soup—right in their back yard!"

"Very interesting, indeed," I admitted. "This map shows clearly the short and long paths from Australia to all parts of the world. The "down under" paths look mighty peculiar to one "up here," don't they?"

"Tell me something about long-path propagation" said Pendergast, as he placed the Great Circle map in the back of his log book.

"Well," I replied long-path propagation has been known for many years. There's no law that says radio waves have to stop once they have been reflected around the earth. In fact, observers have noted radio waves having multiple echoes, indicating they have travelled more than once around the world.

*48 Campbell Lane, Menlo Park, CA 94025

Fig. 1—"The World Turned Upside Down." A great circle map of the world centered on Adelaide, Australia. The "long path" is shown around the perimeter of the map.

"I remember during peak conditions on 20 meters when it was possible to hear your own, and other local signals, coming back around the world. The round-the-world signal was very strong. In fact, the round-the-world signal of one local amateur, who was partially hidden from me by a hill, was quite a bit stronger than his ground-wave signal."

"Are long-path signals heard only on 20 meters?", asked my friend.

"No," I replied. "Some of the strongest and most consistent long-path signals are heard on 15 meters. That band is coming back to life now, so you'll probably hear long-path signals very soon. Forty meters has plenty of long-path openings in the morning, particularly between the West Coast and Europe. Long-path winter openings are fairly common on 80 meters, too. But the signals on that band are quite weak.

"As far as 10 meters goes, I have only observed one long-path opening on that band during a sunspot cycle peak. But others have observed long-path openings, too. I would say that they are less frequent than on 15 meters. Long-path propagation seems to peak right around the 15 meter band.

"It is also thought that the MUF is higher for long-path openings. Cases of long-path propagation have been reported on 15 meters when that band was not open to the same location via the short path. So my guess is that long-path propagation will become more and more important on 20 and 15 meters during the coming years.

"Anybody can play the game, even though you don't have a rotary beam. However, you'll be able to tell a long path signal on many occasions as it can have a "flutter" to it similar to that on signals passing through the auroral zone. But not all long-path signals have a flutter. A rotary beam will quickly tell you the direction of the signal, in any case."

"Turning from propagation to antennas," said Pendergast briskly, "What's new?"

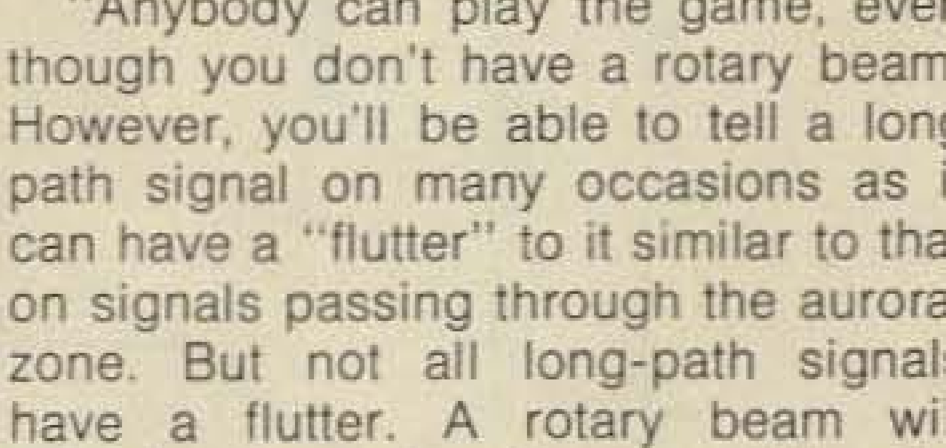

Fig. 2—A wideband antenna tuner for a 30 foot vertical whip, as used in British Marconi equipment. Capacitor at right is whip capacitance to ground through the mount. (Drawing courtesy of RSGB)

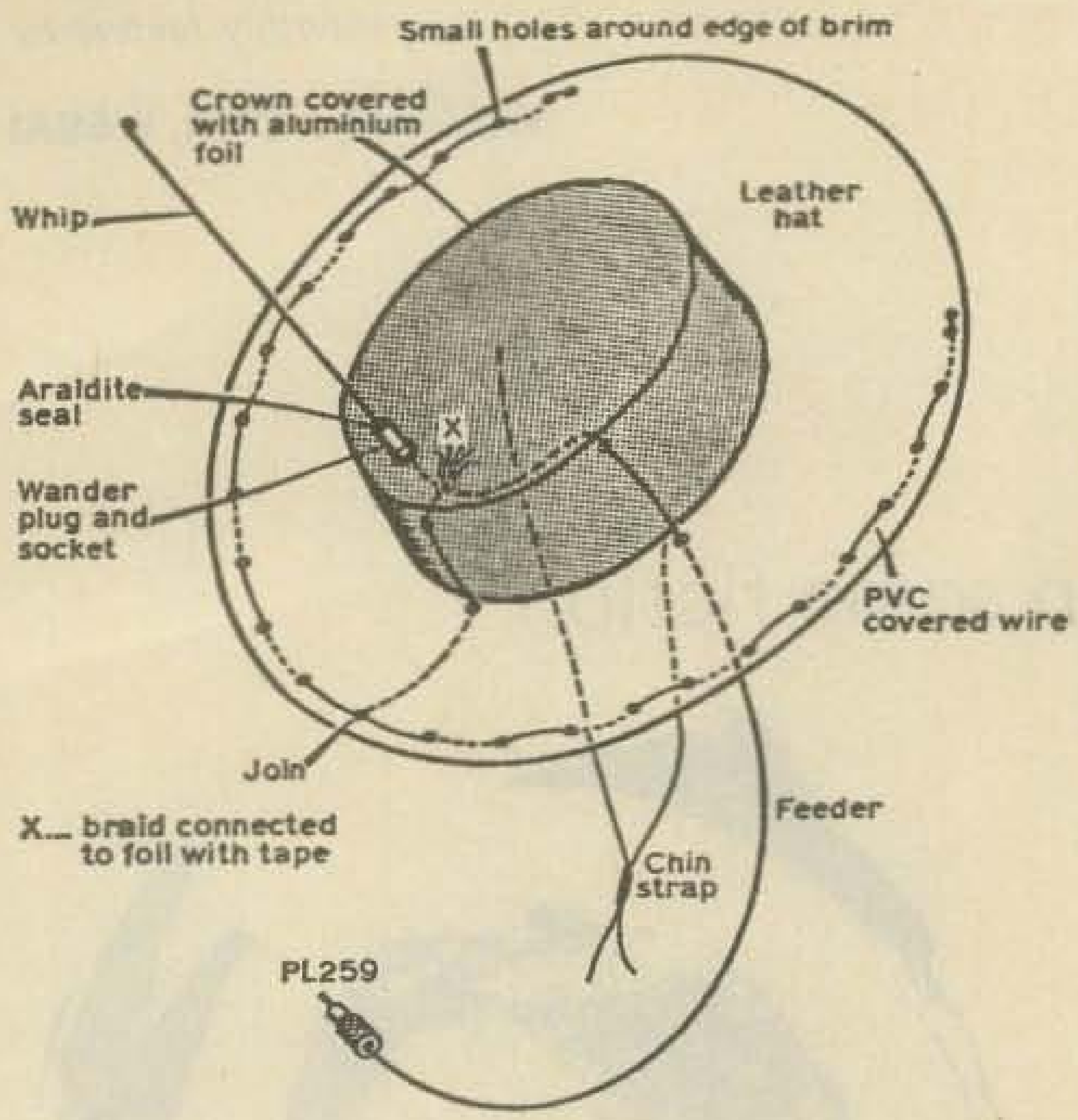

Fig. 3—The "Gaucho" hat-antenna of G4BWE. Mounted on a leather hat, this 19-inch whip provides a much better signal than a "rubber-ducky" antenna. While the "Araldite" seal and "Wander" plug are unknown in America, a good guess is that a BNC connector and epoxy would do the job.

"Well, I've seen a couple of items in *Radio Communication*, the monthly magazine of the Radio Society of Great Britain, that would interest you. The first is a universal antenna tuner that matches a 30 foot whip antenna over the range of 1.5 MHz to 30 MHz (fig. 2). A 50 ohm to 25 ohm wideband transformer is used (no details given). All that is then required are a variable capacitor and a rotary inductor.

"At the low end of the spectrum, the 30 foot whip "looks capacitive" at the feedpoint, passing through resonance around 7 MHz, and then "looking inductive" up to about 11 MHz when it again becomes "capacitive." The equivalent series resistance is about 2.5 ohms at 1.5 MHz, climbing to about 500 ohms at 11 MHz, then falling to about 50 ohms at the higher frequencies.

"Using a high-Q rotary inductor and a good ground system, the antenna efficiency remains remarkably high

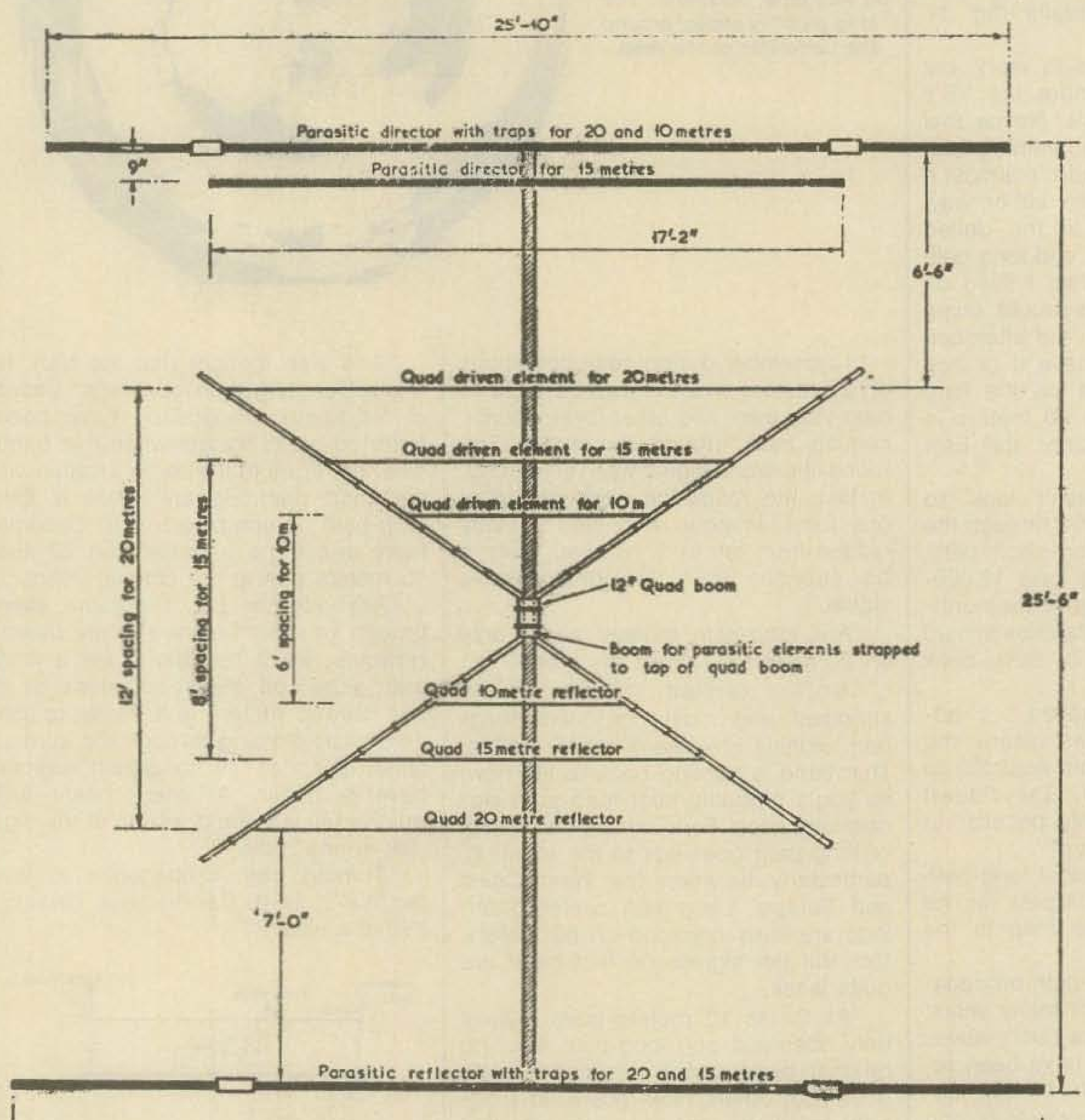

Fig. 4—The plan for the G3NVA "Quagi" antenna as described in the British "Short Wave Magazine." The two element spider Quad has Yagi-type reflector and director added for extra gain.

over the whole tuning range. The English design is automatically tuned when the frequency is changed, but in an amateur-built version, this is not necessary."

"Anything else of interest from the RSGB?", asked Pendergast, as he copied the antenna design into his overflowing notebook.

"One more item," I replied. "Look at fig. 3. This is a 2 meter "hat" antenna designed by G4BWE. This is a fine idea for a hand-held unit, as it puts the antenna as high as possible above ground and minimizes body absorption. G4BWE started with a leather "gaucho" (cowboy) hat. A home-made 19-inch whip is attached to a small coaxial connector which mates with a receptacle mounted on the edge of the hat. There's a ground plane made of aluminum foil in the domed crown of the hat which is attached to the shell of the plug. The ground plane is extended in area by weaving a length of insulated wire through a pattern of small holes around the perimeter of the brim; this counterpoise wire is also connected to the aluminum foil ground plane. Miniature coaxial line connects the hat antenna to the hand-held unit and a fancy chin strap keeps the hat antenna in place."

"Hooray!," cried Pendergast. "And how about a Tyrolean hat from Austria, with the antenna carefully threaded through the feather?"

"Why not?," I rejoined. 'Only thing is, don't put your head down, or you may catch your neighbor in the eye with the antenna. Make sure the tip of the antenna is bent in a circle, or has a ball on it."

"I gotcha," said Pendergast, as he made a qualifying remark in his notebook.

"One more thing before we leave England. There has been a lot of talk recently about using Yagi parasitic elements with a Quad driven element. The v.h.f. boys speak quite highly of such a design.

"The idea has merit, as it seems to provide additional gain over a similar antenna using a straight dipole element. And it eliminates the hassle with the bulky Quad reflector and director elements. Using a Quad driven element seems to add one or two decibels power gain to an equivalent Yagi design, so there's a lot to be said for the idea. Some fellows call the antenna a "Quagi" beam. There's a great article about the v.h.f. Quagi by my friend Wayne Overbeck, K6YNB, in the April, 1977 issue of *QST*. No doubt these principles could be applied to a 20 meter beam antenna.

"In truth, this has already been done. In May, 1963, G3NVA wrote a very comprehensive article about a combination Quad-Yagi in the British *Short Wave Magazine*. Look at fig. 4. This is a plan view of a tri-band beam for 20, 15 and 10 meters. Separate Quad driven elements and reflectors are used for the three bands, in combination with a trapped Yagi reflector for 20 and 15 meters and a trapped Yagi director for 20 and 10 meters. A separate Yagi parasitic director is used for 15 meters.

"This adds up to a formidable antenna. On 20 meters, there are two reflectors and two directors. That is, a Quad and a Yagi reflector and a Yagi director. On 15 meters, there are a Quad and a Yagi reflector, and a Yagi director, separate from the 20/10 meter director. On 10 meters there are a Quad reflector and a Yagi director. This will all sort into place if you study the drawing."

"That's a pretty impressive structure," admitted my friend. "And it all fits on a boom less than 26 feet long. A spider arrangement is used for the Quad elements, I see. In fact, the antenna could be made in two parts—the tri-band Quad, and the long boom with the Yagi elements. I would think that some enterprising owner of a spider Quad might like to make up a strap-on assembly with the Yagi elements and see if it does any good!"

"The Quad driven element does exhibit substantial gain over a dipole driven element," I admitted. "It might be interesting to substitute a Quad loop for the driven element in a Yagi. It's easy to do and the results would be very interesting."

Pendergast reached into his shirt pocket and brought out a drawing of an antenna. "I worked W6TYP on 160 meters a few months ago and he had such a robust signal I asked him what he was using for an antenna. And this is what he sent me." He tossed the drawing on the table (fig. 5.). "In addition to a good 160 meter signal, the antenna also works well on the higher frequency amateur bands. The inductor at the end is adjusted for lowest s.w.r. on 160 meters."

"I've heard W6TYP's signal on 160," I said. "What does he use for the ground connections?"

"He uses a combination of ground rods, cold water pipes and radials at the station end, and ground rods plus one or two radials at the far end. The grounds are connected together by a 210 foot length of wire buried a few inches below the soil. W6TYP measured the ground loss and figured the antenna to be about sixty-four percent efficient. And that's very good for 160 meters."

"Nice," I remarked. "I am always interested in 160 meter antennas. Low frequency antennas are always a prob-

(Continued on page 74)

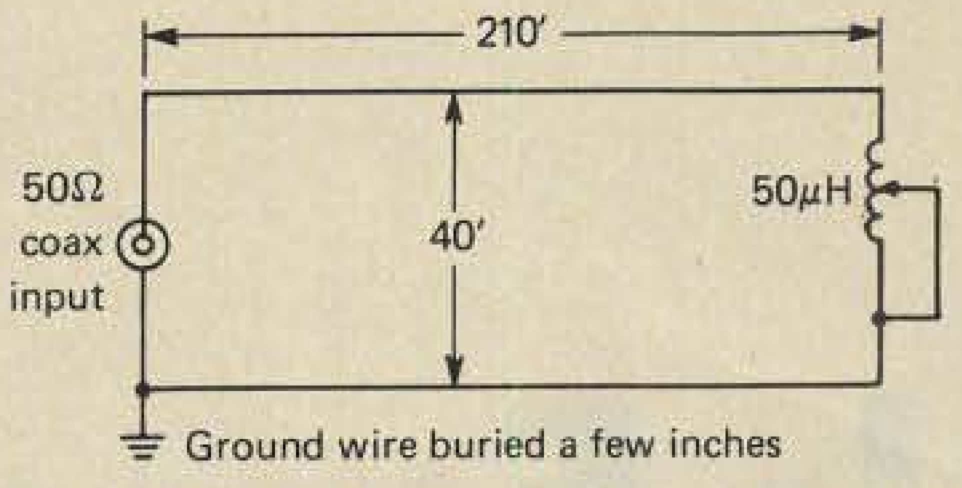

Fig. 5—The W6TYP "loop" antenna for 160 meters. The inductor is adjusted for lowest s.w.r. at the operating frequency. The antenna also works well on higher frequency bands.

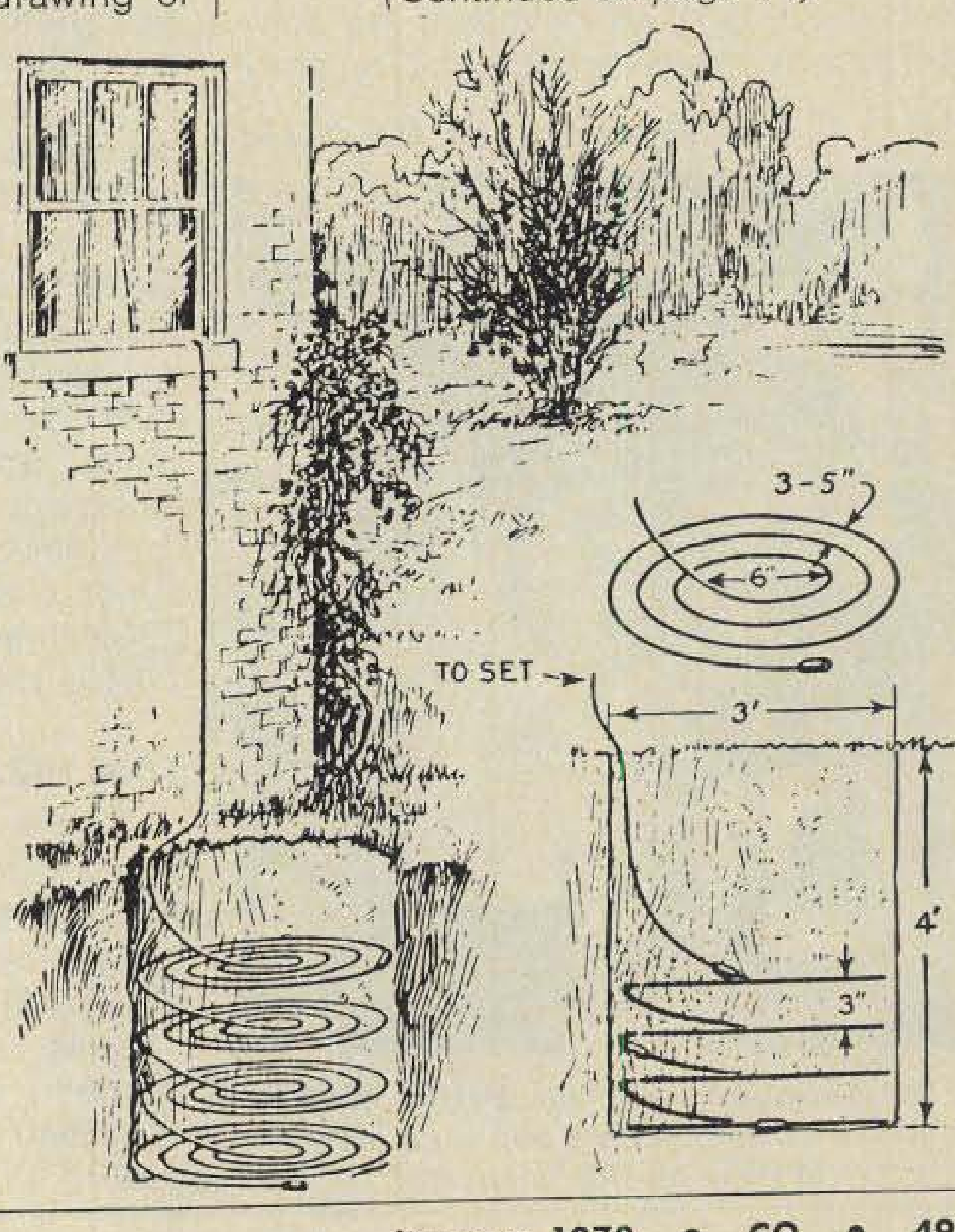

Fig. 6—The old-timer of 1928 knew all about underground antennas!

In Focus *(from page 52)*

last QSL card needed for *CQ's* 100 Countries-2 Way SSTV Award! I believe that Neville's will be the first claim for this award from Europe. This means a "double first" for good ole England, since G3IAD was also the first European to receive the WAS-2 Way SSTV Award. Congratulations Neville, well done!

Neville is an inveterate DXer whose expeditions around the UK and elsewhere have provided much sought "country" prefixes to hams everywhere. In 1975, as GD3IAD, Neville provided many slow scanners with QSOs from the Isle of Man.

At the present time, G3IAD is head of the Technical Studies Department in a college for the training of disabled people. Prior to arriving at his present location, Neville was really "on the move". Some of his previous calls are: VS6CE, VQ4GC, VQ5GC, VQ3GC, 5H3GC, 9Q2VB, and 9J2VB!

The accompanying photograph (fig. 6) shows Neville relaxing in his well-equipped "shack".

At this point, Neville's "country score" has climbed to 104, so it's a safe bet that one of the first "150 stickers" will find its way to Nottingham.

Final-Final

Don't forget that there are amateurs all over the world who want to know *what* you're doing, and *how* you're doing it. And, they want to know what you are doing *with* slow scan television. Please keep those letters and photographs coming my way. Same old address on our windswept hilltop, 2112 Turk Hill Road, Fairport, N.Y. 14450. Best regards, Bill, W2DD

Antennas *(from page 49)*

lem for most amateurs, who don't have unlimited ground space to play around with."

I handed Pendergast a brochure. "Before you leave, you might want to look at this. An outfit by the name of *Bartol Company* at 901 West Franklin Street, Kenton, Ohio 43326 makes very attractive residential flagpoles of tapered aluminum. They sent me their sales sheet on a 20 foot flagpole. It's made of 6063-T6 seamless extruded aluminum and tapers from three inches in diameter at the base to two inches in diameter at the top. It has a gold anodized ball at the top, with a pulley underneath it. At the base is a cleat for the rope for the flag. The flagpole rests in a steel pipe ground rod."

"Not bad," exclaimed my friend. "That would make a perfect 'invisible' vertical antenna. How much does it cost?"

"About one hundred and twenty five dollars," I replied. "And maybe they make 'em higher, too. It's worth investigating if you are interested in an attractive looking vertical antenna."

"Here's a *better* invisible antenna," remarked Pendergast. "My old buddy W6VAT sent me this drawing (fig. 6) of an underground receiving antenna. The drawing was published in a 1928 issue of *Popular Mechanics*."

I looked at it and asked, "How long is the lead-in from the underground antenna to the receiver?"

"You have a suspicious mind," rebuked my friend. "You assume the lead-in does the work?"

"It could be," I admitted. "Stop pulling my leg. I have some interesting information on underground antennas that I'll give you the next time I see you. The underground antenna is no joke."

* * *

(Note). W6SAI is the author of two books that cover Quad and Yagi antennas. The books are available from Radio Publications, Inc., Box 149, Wilton, CT 06897. They are: "All About Cublical Quad Antennas" ($4.75) and "The Beam Antenna Handbook" ($4.95). Add 40¢ for postage and handling per book. 73, Bill, W6SAI

QRP *(from page 46)*

the common ground foil strip. The proper run of the ground foil can be figured out two ways: first, check the schematic, and locate the ground end of the specific components on the p.c. board design, and draw the ground foil in; 2.) check the p.c. board deign, and note those component "holes" which have nothing but the component connected there—these are where the ground foil should run. The foil can be drawn in according to the following directions: 1.) Draw a line from the loose end of the 12.1 V zener southwest, passing under R4, around "T", under R8, and connect to loose end of R3; 2.) Draw a line from loose end of zener south along side of board to its bottom, turn west, and connect to end of R10, northwest and connect to loose end of R6 (just above "C"), and then to C3, ground symbol, and end of R7. That will do the trick.

I certainly hope that any of you who tried to build the R.I.T. caught the omission of the ground foil strip and figured it out. It exasperates me to have put all that time into a circuit, and then have the effort nullified by an incorrect schematic or p.c. board template.

Conclusion

Well, gang, that it for this month. Keep the mail coming, but send it directly to *CQ* headquarters, rather than to me in SD. We will try to arrange things so that batches of mail can reach me periodically for inclusion in "operating reports" columns. For now, happy QRPp'ing and 73,

Ade, K8EEG

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I certify that the statements made by me above are correct and complete. (Signed) Richard A. Cowan, Publisher.

a monthly feature by

WILLIAM I. ORR, W6SAI

Antennas

Design, construction, fact, and even some fiction

Pendergast slit open the fat envelope with a practiced hand. He extracted a bulging bundle of photographs and studied them intently. There was a long silence. Finally, I said, "What are the pictures? Are they porno?"

My friend chuckled with delight. "They are better than that", he replied with a grin. "Look at these. When Don, K5DUT, in Cow Town (Fort Worth) sees them, why, he'll cut his throat with a rusty razor blade".

"Do you mean that Cow Town is loosing its claim as the Quad Antenna capitol of the world?", I asked.

In reply Pendergast tossed the photographs across the table to me.

"Look at these pictures from John, K5JA, in McKinney, Texas", he replied. "How about a six element Quad? A tribander for 20, 15 and 10? And how about adding a two element 40 meter Quad to that? And all on a 40 foot boom! What do you think of that?"

"Did I ever tell you the story about the Texans? Well, once an airliner landed in Dallas and everybody was surprised when a whole plane load of midget Texans got off. They all had cowboy boots and Stetson hats and chaps and spurs and the works. However they were only six inches high. Then somebody said to the pilot that

*48 Campbell Lane, Menlo Park, CA 94025.

Fig. 1—The Monster Quad of K5JA (McKinney, TX) on the ground, ready to go up the tower. Six spiders are used on a 40 foot boom. A two element 40 meter Quad is on the larger spiders.

Fig. 2—K5JA putting the finishing touches on the beam. There are six elements on 20, 15 and 10 meters. Boom diameter is three inches and antenna weight is about 200 pounds.

they never saw Texans six inches high before. And the pilot said, Well these are . . . (Editor's note: *remainder of joke censored*) . . ."

Pendergast laughed until tears came to his eyes. "That's a great story. I'll have to remember it", he said.

"Suppose you let me see the pictures before you dissolve", I commanded. I took the photos from Pendergast's grasp and studied them.

"Fig. 1 gives you a good idea of K5JA's Monster Quad. The whole antenna weighs close to 200 pounds. The boom is 3" in diameter and 40 feet long. In this picture it is laced to the tower for assembly. The array consists of six elements on 10, 15 and 20 meters having 8 foot spacing. The two larger spiders also have 40 meter elements on them. That makes a two element beam for 40 meters with 24 foot spacing.

"Fig. 2 is a closeup of K5JA atop a 20 foot ladder working on the antenna. Each antenna has its own coaxial feed system".

"How tall is the tower?", asked Pendergast in a subdued tone. "No wonder these guys beat me out. Jeepers".

"John has a 160 foot tower—among others", I replied. "Look at fig. 3. Here is the crew hard at work. K5JA is at the right, working on an element. The other DXers are having a siesta at the foot of the tower. And notice the nice, wide-open countryside".

Pendergast sniffed. "That's OK if you like countryside".

I ignored the remark and continued. "Fig. 4 shows K5JA at the top of the 160 foot tower and a catenary cable slung down. The idea is to pull the Monster Quad up the cable, clearing the guy wires on the way up. The Quad is on the catenary cable in fig. 5 and K5JA is starting up the tower. Everything looks very ship-shape, doesn't it?"

"I have to admit it does", replied

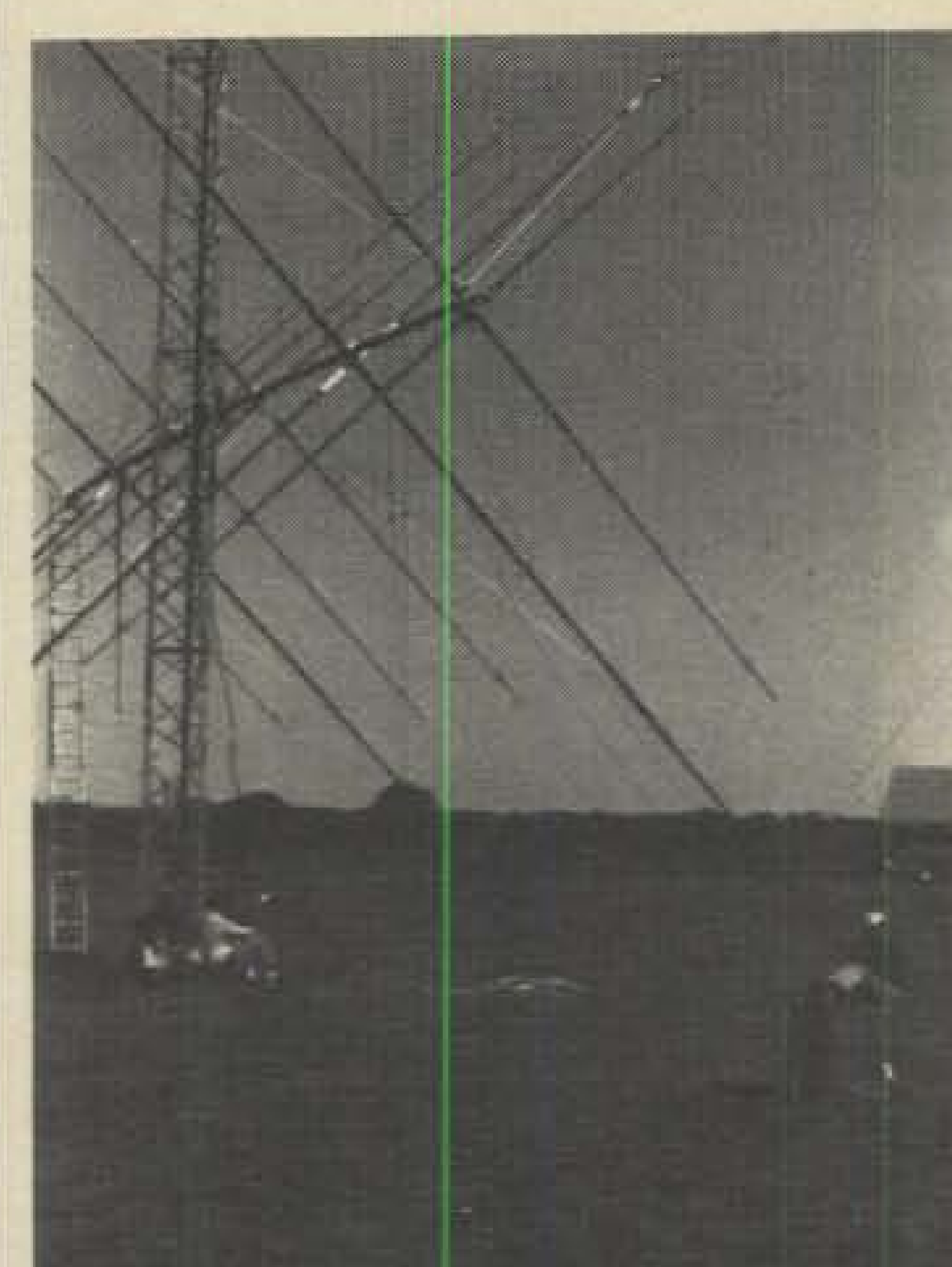


Fig. 3—K5JA hard at work on 40 meter element. Helpers are taking a noontime siesta. Twenty foot ladder in background is used to work on antenna boom when Quad is lashed to tower base.

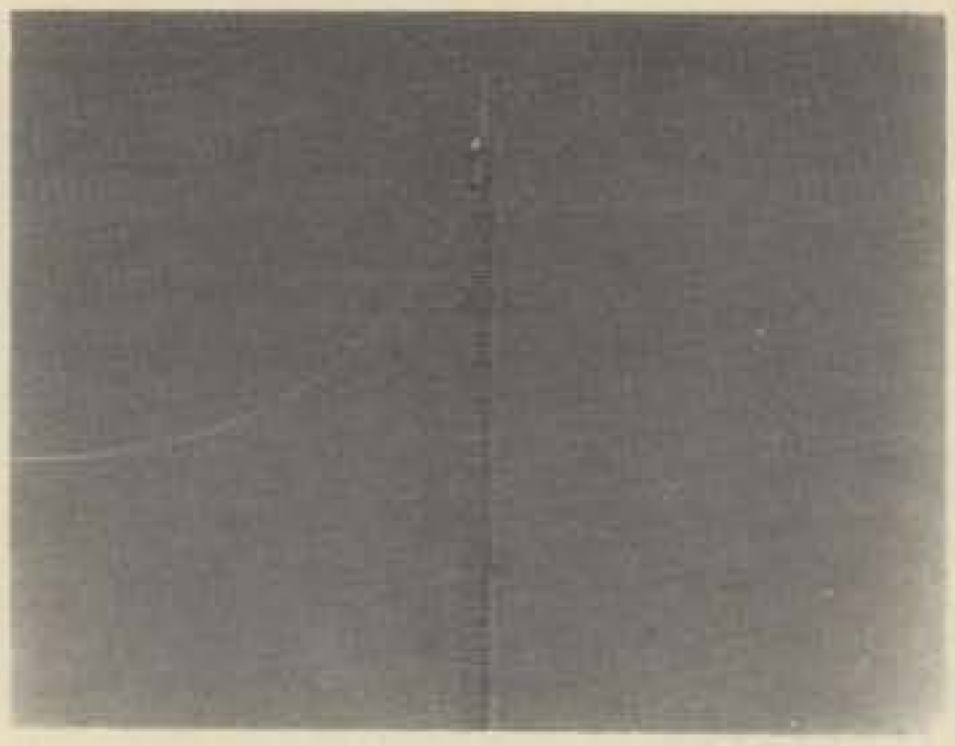


Fig. 4—The 160 foot tower at K5JA with the Old Man at the top. The Monster Quad will be run up the catenary cable in the foreground. A mast is rigged at top of the tower to pass power cable used to tug antenna upwards.

Pendergast with interest. "They certainly do big things down in Texas, don't they?"

"Look at fig. 6", I exclaimed. "Now the Monster Quad is on the catenary cable, just starting up the side of the tower. This is about the stage of the game where—with my luck—I'd drop the antenna! And if you look at fig. 7, you'll see the Quad about half-way up the cable . . . on the way to the top. And *voila!* Look at fig. 8. The Quad is at the top of the tower, safely, and in one piece!"

"Wow", said my friend. "What a project! He looked at the photograph more closely. "What is that object at the bottom of the tower?", he asked.

"That's a two element Mosley F-402 beam for 40 meters. And it's not at the bottom of the tower, it is at the 80 foot level and is aimed at the Caribbean area".

Fig. 5—Final inspection is completed and K5JA returns to ground level. The trick will be to pull the Quad to the tower top without getting entangled with tower guy wires.

"Well, I'll be damned", said Pendergast almost to himself. "Why would anybody want a two element miniature 40 meter beam at 80 feet when they have a two element Quad at 160 feet? Seems very odd".

"Simple", I replied." John says the angle of radiation of the high Quad is so low that he overshoots the Carribean area. In-close, he uses the Mosley at 80 feet. But for long-range 40 meter DX, the high Quad is at least 10 dB better than the Mosley at 80 feet. What do you think of that?"

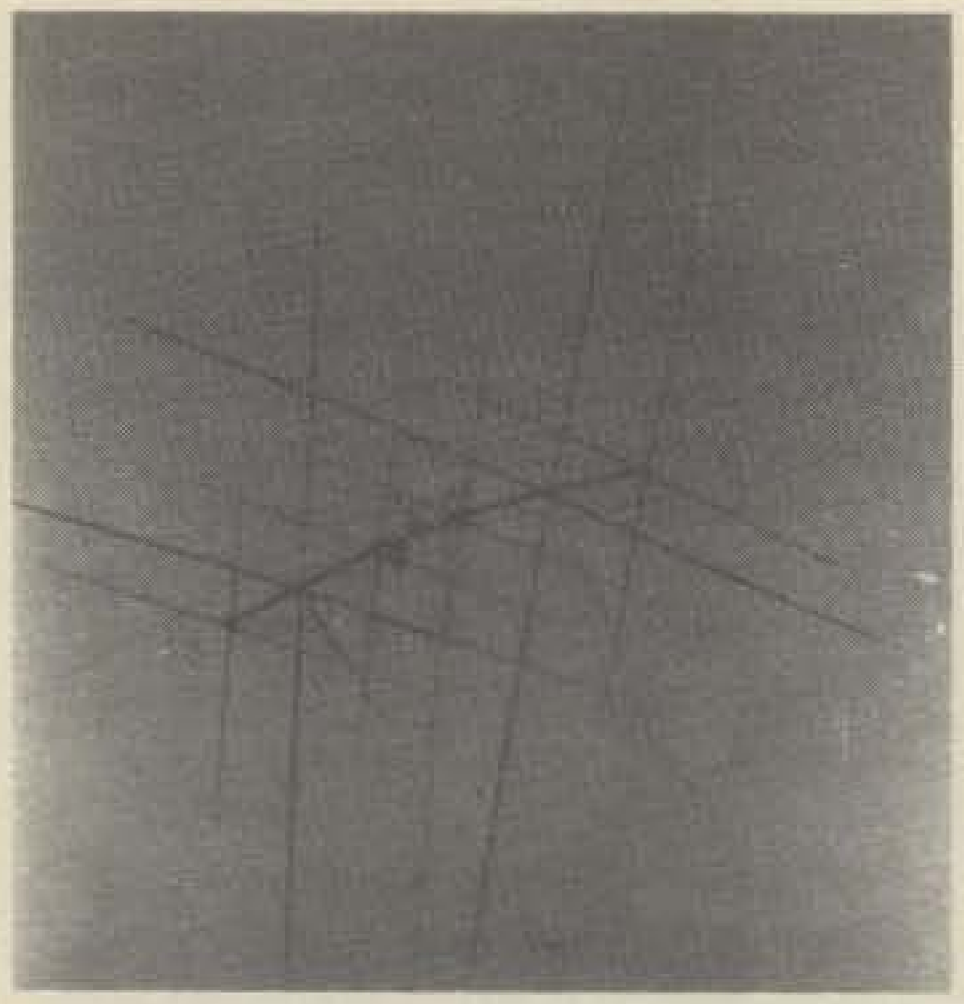


Fig. 6—Operation Skyhook is underway! Huge Quad is being pulled up the catenary cable and is about 20 feet clear of the ground.

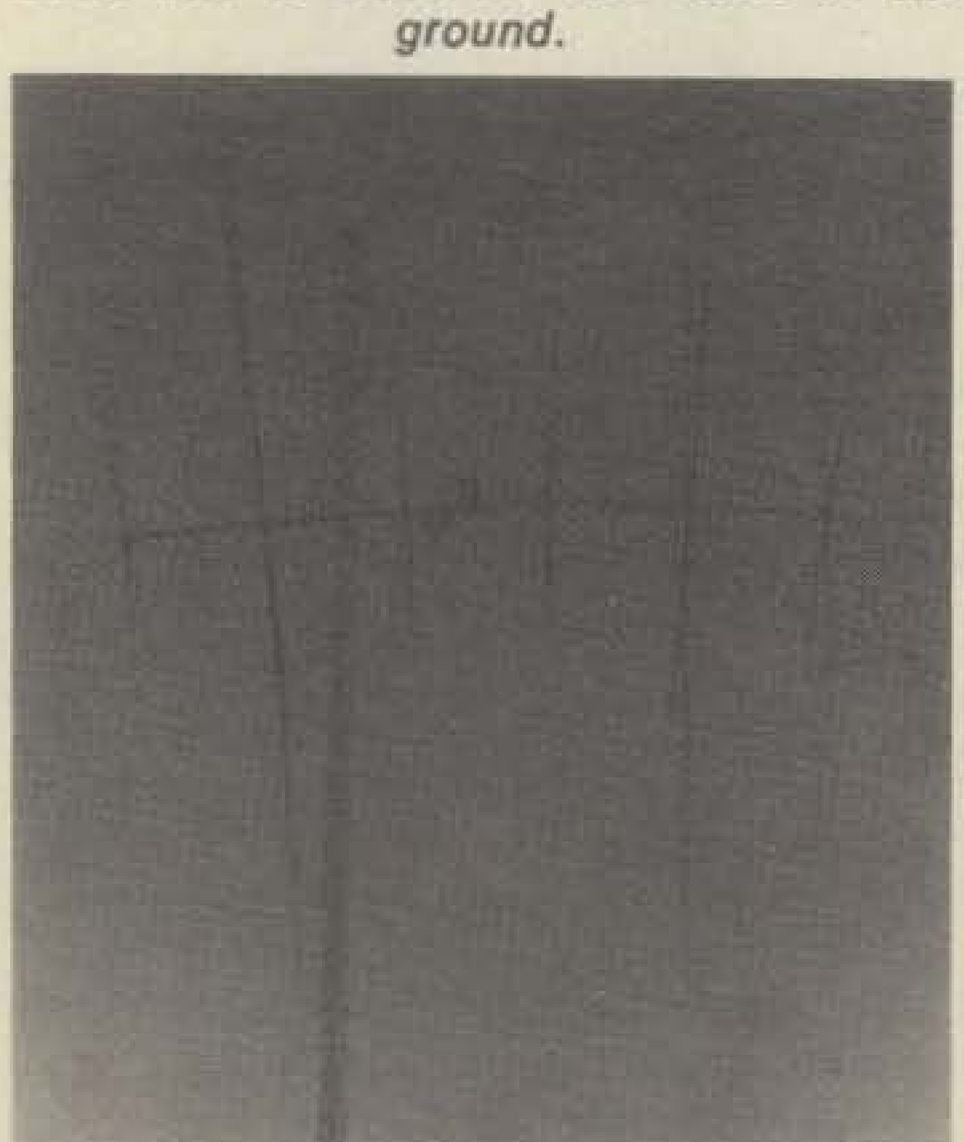


Fig. 7—Viewed from the ground, the Quad progresses up the catenary cable. The two large 40 meter elements are visible in this view. Quad is about 50 feet in the air.

"Amazing", replied Pendergast. "And does K5JA have any other antennas to fill in the gaps?"

"Certainly", I said. Look at fig. 9. At the top of the first 160 foot tower is the Monster Quad, with the two element 40 meter beam below it. The second 160 foot tower in the rear has a four element 20 meter beam on it. That's a nice combination".

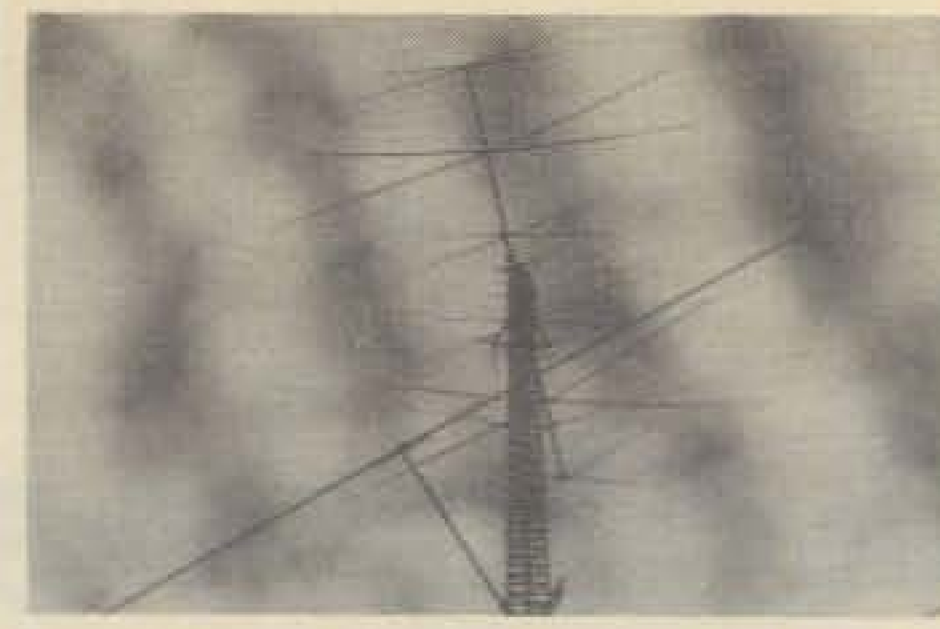


Fig. 8—The Monster Quad safely atop the 160 foot tower at K5JA. A two element beam is affixed to the tower at the 80 foot level for "local" coverage.

"How does the six element Monster Quad on 20 meters compare with the four element Yagi?", asked Pendergast eagerly.

"John says the Quad has the edge, but not by much. Sometimes they are equal on tests, and sometimes the Quad is better. But the Yagi is never better than the Quad".

Pendergast sighed deeply. "Seems to me it's a heck of a lot easier to put a Yagi up than a Quad".

"Perhaps", I replied. "But you have the advantage of multiband operation with the Quad, as opposed to a single-band Yagi. "I think you are just jealous".

Pendergast picked up the last photograph (fig. 10). "Nice sky shot", he remarked.

"Just to make you feel better, and to realize that K5JA isn't the only Big Shot with a Monster Quad, here's a photo of the Quad of K2ON. Look at fig. 11. This array is five elements on 20 meters and *seven* elements on 15

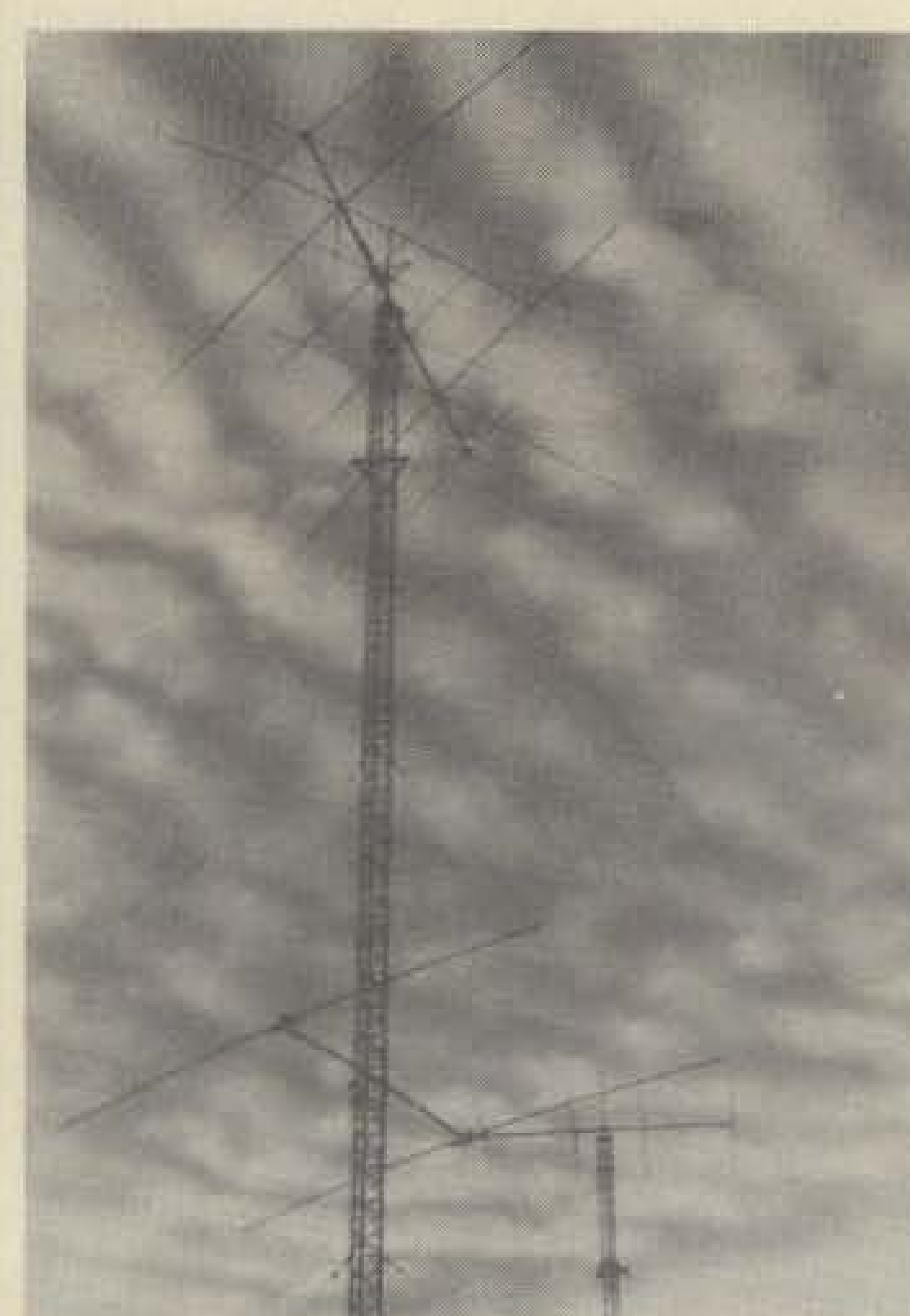


Fig. 9—The K5JA monster Quad with the two element beam below it. In the background is the second 160 foot tower with a wide spaced four element, 20 meter beam on it.

Fig. 10—The four element Yagi at K5JA has been replaced with a four element, triband Quad and a stacked, two meter array. You can do a lot of things if you have the time, space and money!

and 10 meters. I don't know any of the details, as I got the pix of the K2ON Quad from a friend. But it proves that all the big signals don't come from Texas!"

"I must admit I am mentally exhausted from looking at pictures of monster antennas", admitted my friend. "Doesn't *anybody* have a down-to-earth amateur station like mine?"

"Well, I got a note from Joe, WB5LMN, that dispels the big Quad idea. Joe says, 'Just so you won't think that all the Big Guns here in Cow Town (Fort Worth) are using Monster Quads, I am enclosing a picture of perhaps the Top Gun in the area (fig. 12). The antenna is a genuine three element *Bandsmasher* on a 12 foot boom at 13 feet. The antenna exhibits 22 dB gain over a wet noodle.' "

"During the recent DX contest this antenna has demonstrated its superior performance over the Monster Quads over the short path (Fort Worth to Bugtussle). So it all goes to prove that quality, not quantity, is what really counts in snagging those rare ones".

Pendergast snatched the photograph from WB5LMN. He turned it over and read on the back, "This hamshack was spotted in a vacant field near Arlington, Texas. Don't know who it belongs to, but thought you might get a kick out of the picture. 73, and thanks for the fine column each month".

"Well", I said. "Obviously WB5LMN is a gentleman and an astute observer of human nature. This disproves the story I told you earlier about the six inch high Texans!" ■

Fig. 11—Showing that all the big signals don't come from Texas, K2ON put up this seven element Quad array. It has five elements on 20 meters and seven elements on 15 and 10 meters. OSCAR satellite antenna is in foreground.

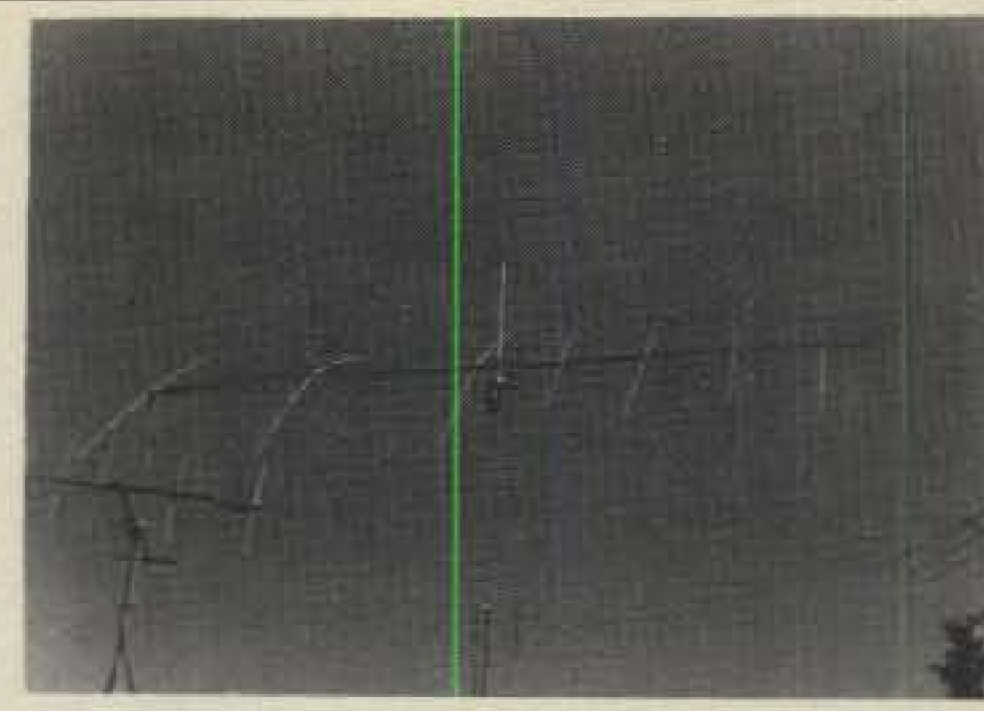


Fig. 12—Just to prove that most Texas amateurs are down-to-earth fellers, WB5-LMN sent in this photo of typical Big Gun station near Fort Worth (Cow Town). Antenna has 22 dB gain over a wet noodle, claims WB5LMN.

a monthly feature by

WILLIAM I. ORR, W6SAI

Antennas

Design, construction, fact, and even some fiction

Pendergast shuffled into the shack, hands deep in his pockets. He kicked the door shut with his foot and slumped down in the operating chair. With a deep sigh he looked at a pile of unanswered QSL cards on the desk and with a single movement he swept them into the wastepaper basket.

"I've got the megrims", he said in a low voice. "Guess I have lost interest in DX".

"Who beat you out in what pile-up?", I asked.

"I didn't work Clipperton Island", he admitted. Then, after a long pause, he said, "I was calling them with the dummy load connected to the transmitter".

"That wasn't very smart", I observed. "Cheer up. In twenty years time, there'll be another DX-pedition to Clipperton".

Pendergast smiled wanly. "That's right", he said with no enthusiasm. "I guess I'll just have to wait my turn as a second-class citizen".

"Cheer up", I responded. "I didn't work this Clipperton DX-pedition either. Of course, I have QSL cards from FO8AJ and FO8AT so it didn't . . ."

Pendergast thumped the table with his fist. "That's just about enough", he barked. "I'm sorry I brought it up. Let's change the subject from radio and talk about antennas for a change!"

"Agreed", I replied hastily. "For starters, how about a note I received from WA2BLY in Alplaus, N.Y. He's sent me a picture of his 15 meter Delta loop beam (fig. 1). He says it is simple to build and easy to get working. It is a two element job with the dimensions shown in fig. 2. The bottom of the Delta loop is just a few feet above the roof of the house. Tuning is simple—sit on the roof and use a s.w.r. meter to adjust the two capacitors and the matching wire for the lowest s.w.r. reading. It took about two minutes to hit 1.1-to-1.

"Francis says he uses 9.5 foot spacing between the elements. The boom is 2″ diameter PVC plastic drain pipe and the top portions of the Delta loop are aluminum tubing. The mast is 2″ steel pipe bolted to first and second floor roof rafters of the house. The antenna is turned by the Armstrong method from the ground.

*48 Campbell Lane, Menlo Park, CA 94025

Fig. 1 – The Delta loop beam of WA2BLY. This inexpensive 15 meter beam is made of wire and PVC plastic drain pipe. An Omega match is used to provide a 50 ohm termination for the coaxial transmission line. Boom length is 9.5 feet See fig. 2 for details.

"WA2BLY goes on to say he easily works Japan and Europe in the Novice band and that he considers he has a rather poor location, being in a valley with large trees surrounding the antenna".

Pendergast brightened up a bit as he looked at the photograph. "Yes, that looks nice", he admitted. "I guess he can lower the antenna from the ground and work on it at roof level".

I handed Pendergast a second drawing. "You might be interested in this antenna of VE3FHS that was described in *World Radio* newspaper (fig. 3). It is a multiband vertical antenna that permits bandchanging to be done in the shack. No traps are used in the antenna at all.

"Basically, it is a 22 foot whip. It is about 1⅛ wavelengths long, at 10 meters. On 15 meters it is about a half wavelength long and on 20 meters it is ⅝ wavelength long, which provides some gain and a good, low angle of radiation. The whip is less than a quarter-wavelength for 80 and 40 meters, but still long enough to put out a good signal.

"The whip is fed with a transmission line cut to one electrical wavelength on 40 meters. Line length, then, is a half-wavelength on 80 meters, two wavelengths on 20 meters, three wavelengths on 15 meters and four wavelengths on 10 meters. In each case, the line acts as a one-to-one transformer reflecting the input impedance of the vertical whip at the station end of the line.

"It is true that the input impedance of

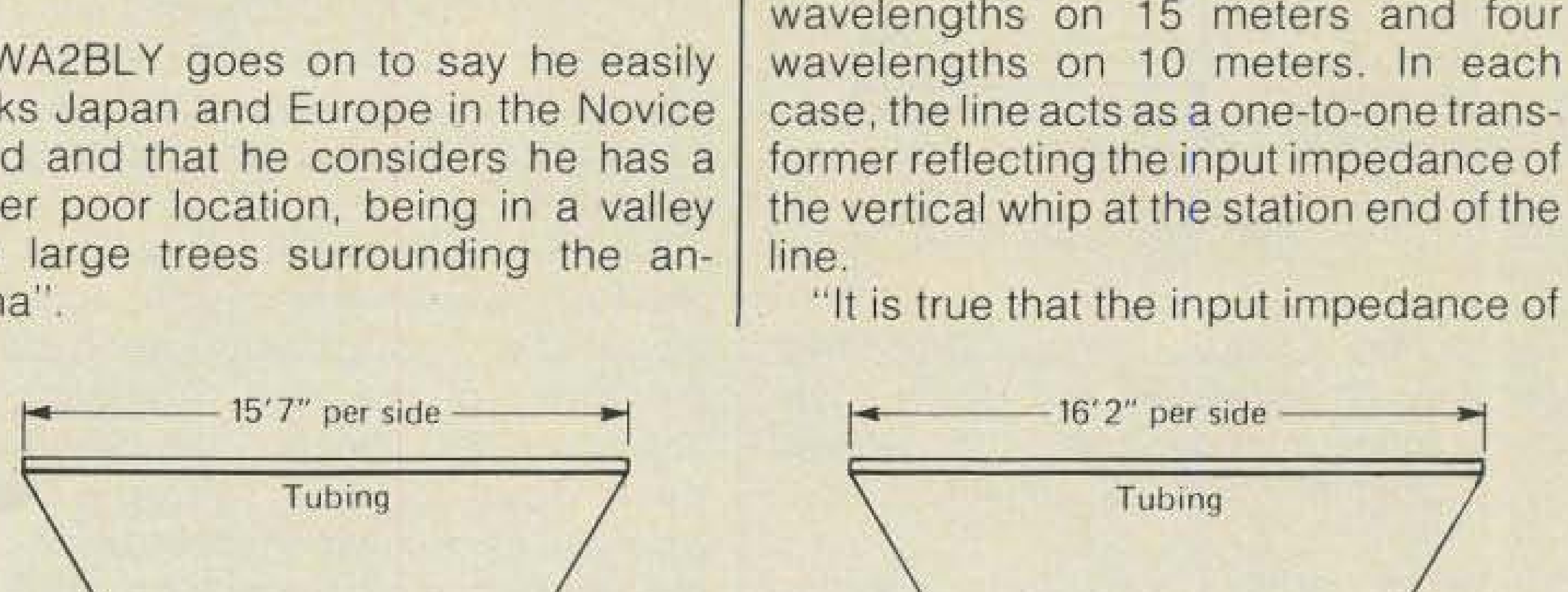


Fig. 2—"Squashed" view of 15 meter Delta Quad. Capacitors are 100pf, double spaced. Matching wire is about 20″ long, spaced 3″ from Delta loop. Adjust capacitors and length of matching wire for lowest s.w.r.

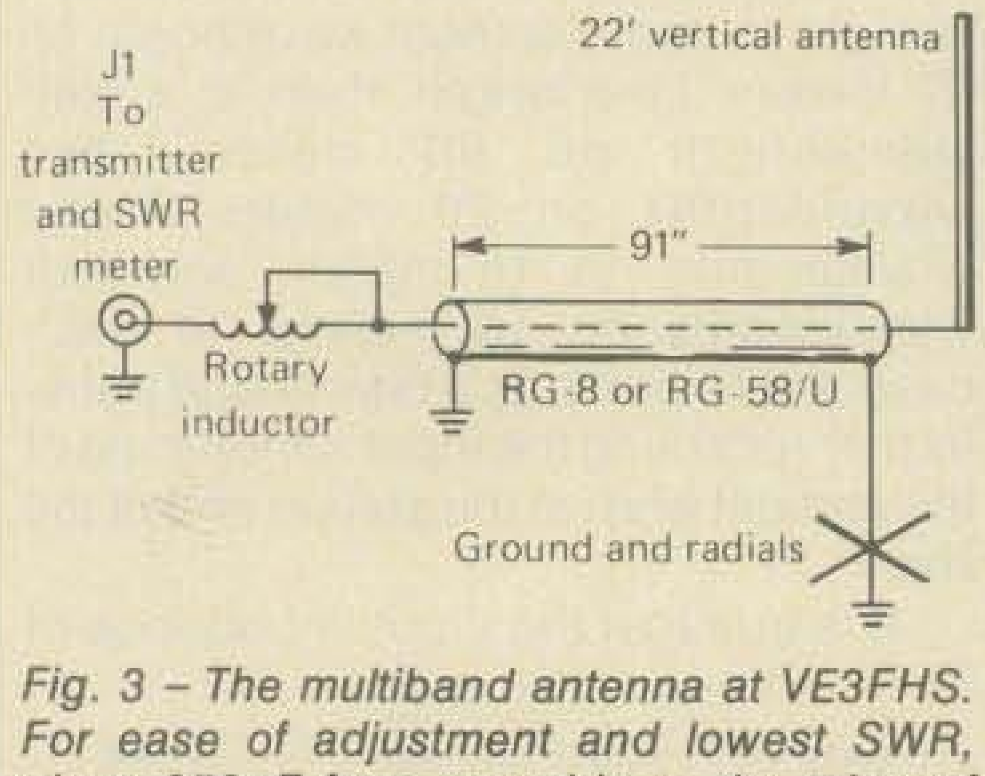


Fig. 3 – The multiband antenna at VE3FHS. For ease of adjustment and lowest SWR, place 250pF from one side or the other of rotary inductor to ground.

the whip varies widely from band to band, but a good match to a 50 ohm line can be achieved by placing enough inductance in series with the line so that

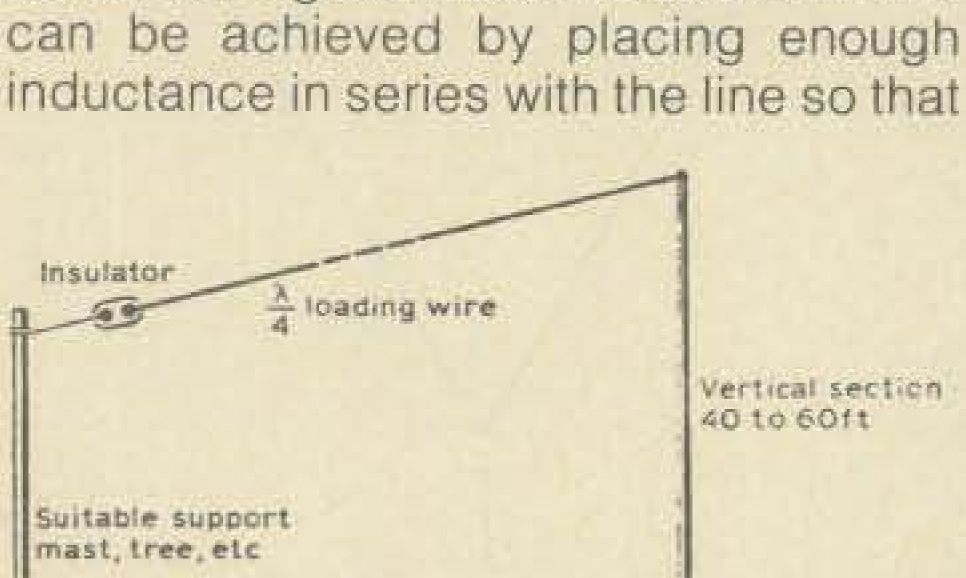


Fig. 4 – The 160 meter experimental antenna at G3XAP. (Drawing courtesy of "Radio Communication".)

the input of the matching device is at a point of high line current. A rotary inductor will do the job nicely, as shown. Or you can use a tapped inductor. Just adjust the inductor for lowest s.w.r. at the operating frequency. The inductor is placed at the station instead of at the base of the antenna for operating convenience.

"A perfectionist will use a roller coil, and he'll have an auxiliary capacitor that he can clip from ground to one side or the other of the coil. Adjusting the capacitor and the coil can knock the s.w.r. down to unity. Those amateurs willing to accept a modest value of s.w.r. at antenna system resonance can forget about the capacitor and just use a tapped coil, which is less expensive than the roller variety."

Pendergast listened intently. Then he said, "You need a good ground system with this antenna, don't you?"

"That's right", I replied. "You need a good ground system with *any* vertical. And I don't just mean ground rods driven into the soil. They are relatively worthless, escept for lightning protection. A good r.f. ground is hard to find so the next best thing is to run out some quarter-wave radials beneath the antenna. Fan them out like the spokes of a wheel."

"How many radials and how long are they?", asked my friend.

"Ah, there you enter the realm of speculation", I replied. "The closer the vertical antenna is to the ground, the greater the number of radials required. Numbers ranging from 60 to 120 are commonly mentioned. However, if the vertical antenna is elevated *above* the ground it is possible to get by with fewer radials. I'd say if you had this antenna with the base about 10 feet in the air you would be satisfied with a lot fewer radials. When I had a multiband vertical (not this design, but one like it) I had four radials for 40 meters and four for 20 meters. This combination also worked well on 15 and 10 meters. I tried adding radials for the latter two bands, but it didn't seem to improve performance. The base of my antenna was on the roof of a one story residence, which put it about 11 feet above ground".

Pendergast drew a graceful picture of the vertical antenna in his notebook and smiled. "I like simple things that work", he said. "This looks like a good multiband antenna for the fellow with restricted space".

"Have you ever seen a simple *directional* vertical antenna?", I asked with a smile.

"That sounds as rare as hen's teeth", replied Pendergast. "How do you get directivity out of a single vertical radiator?"

"It takes a real experimenter to do

that", I replied. "But it has been done. The work by G3XAP of England was summarized in the November, 1977 issue of *Radio Communication*, that fine publication of the Radio Society of Great Britain. He did his experiments on 160 meters and, in fact, achieved the WAC (Worked All Continents) award on that band with only 9 watts input! That certainly speaks well for the efficiency of the antenna!"

"Tell me about it", said Pendergast, as he re-opened his notebook and took his feet off the table. He hesitated, then reached into the wastepaper basket and retrieved the QSL cards. "I must be feeling better", he admitted.

"Well, since G3XAP was space-limited, he put up the antenna of fig. 4 for 160 meters. Basically, it is a short vertical with a quarter-wave loading wire at the top. The antenna was series-tuned to resonance.

"G3XAP noted that the antenna had directivity so in order to run some tests, he made a scaled-down version for 10 meters and made observations on that band. The 10 meter model showed directivity in the direction of the loading wire when it was sloped downwards toward the ground. Maximum directivity was noted when the wire ended in close proximity to the ground and less directivity was noted when the wire was in a horizontal position. Changes in the slope of the wire had little effect upon tuning or loading.

"A second 10 meter model was erected near the first, but in the reverse direction. A switch in the coaxial lines to the antennas permitted the operator to switch back and forth for comparative tests. The directivity between the two antennas amounted to about two S-units.

"Now that the directivity was established, the next test was to compare the signal gain of the model antenna against a quarter-wave 10 meter vertical ground plane antenna operating over the same ground system. The 10 meter model showed a signal loss of about one S-unit when compared to the full-size vertical ground plane".

Pendergast frowned. "If the model antenna has *loss*, then why use it?", he asked.

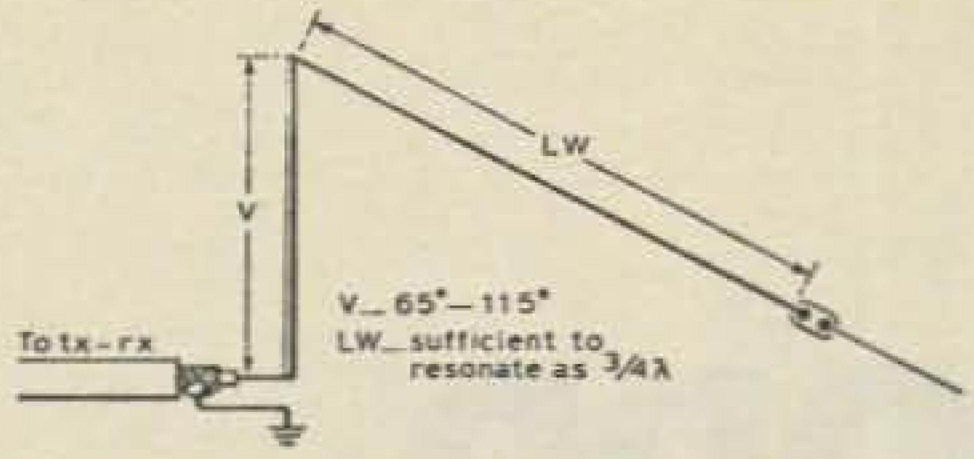
"Well, G3XAP mentions that the 10 meter model antenna was only 3'9" high and the ground plane was about eight feet high. He was sure that surrounding objects had a lot of influence on the little antenna, whereas at a height of 60 feet on 160 meters, these influences would be considerably reduced.

"In addition, if a compromise 160 meter antenna less than 60 feet tall could put out a DX signal that was only one S-unit below that from a full size 160 meter ground plane antenna 135 feet high, then working DX was a distinct possibility!

"Based upon his observations and conclusions, a 160 meter version was built and put on the air. The wire sloped in an easterly direction from England. In a few days the station worked EP2BQ in Iran while running less than 5 watts input and a few months later VK6HD was worked.

"The antenna was now retuned for 80 meter operation. On this band, it took the form of a half-wave loading wire fed by a quarter-wave vertical. Again, operation to the east was very good, but stations from the USA were quite weak, even

(continued on page 87)



Band (MHz)	Vertical length (ft)
1·8	95 — 170
3·5	48 — 85
7	25 — 42
14	12 — 21

Fig. 5 – The G3XAP single wire unidirectional antenna for 160, 80, 40 or 20 meter operation. (Drawing courtesy of "Radio Communication".)

Announcements *(from page 8)*

ship Recreation Center in Johnson City. There will be 4 acres of flea market, technical talks, prizes, etc. Tickets are $2 for general admission, $7 including the banquet. For additional info and/or tickets write: S.T.A.R.C., P.O. Box 11, Endicott, NY 13760.

• Waukesha, WI — The First Annual Spring Swapfest will be held on Sunday, May 14, 1978, starting at 7 a.m. on the grounds of the Waukesha Co. Expo Center. There will be prizes, refreshments, and some indoor space will be available. Admission is $1.50 in advance and $2.00 at the gate. For tickets write: Swapfest, Box 49, North Prairie, WI 53153, (please include s.a.s.e.). This Swapfest is sponsored by the Milwaukee UHF Society, Inc.

• The Society of Wireless Pioneers (SOWP) will celebrate its 10th birthday with an on-the-air CW QSO Party during the full GMT period of May 4 and 5, 1978. The call will be CQ SOWP on all bands, 55 kHz up from the low end. Novice members should use the center portion of each novice band. For the benefit of those who cannot participate for the full time, it is suggested that part-time participants make their CQ calls on the even hours. To qualify for the certificate, members should send a list of contacts, showing date, time, call and SOWP numbers to the Society's Vice Presidnent for Awards, Pete Fernandez, W4SM, 129 Hialeah Rd., Greenville, SC 29607. In addition, a s.a.s.e. must accompany all requests for the certificate.

• Easton, MD — The fourth Annual Easton Amateur Radio Society Hamfest will be held on May 14, 1978, rain or shine, at 10 a.m. to 4 p.m. Location is 5 miles north of Easton, on Rt. 50 at the Talbot County Agricultural Center. Talk-in on 52 and 146.445/147.045 repeater in Cambridge. Some tables both inside and out, good-refreshments, and lots of room for tables and tailgaters. Donation is $2, with an additional $2 for tables or tailgaters. Write: K3ONU,

(Continued on page 95)

Antennas *(from page 63)*

though other European stations were giving the USA stations good reports.

"G3XAP surmised that the antenna had a pronounced null off the back on 80 meters. Shortly thereafter, the loading wire was switched to run in a northwesterly direction. The operator reported a dramatic increase in the strength of American signals, with excellent reports on the G3XAP signal from across the ocean. It was apparent that a highly directional antenna had been de-

veloped having good front-to-back ratio for low-band operation".

"This really sounds *great*", said Pendergast, writing furiously in his notebook. "Did G3XAP conduct any tests on 40 meters?"

"Yes", I replied. "He built a 7 MHz version with a 40 foot vertical section and a loading wire 65 feet long. The wire was trimmed until a low s.w.r. was achieved on 7.005 kHz. Again, excellent signals were noted and good DX contacts achieved with Australia and New Zealand. The direction of radiation could be easily altered by simply changing the direction of the sloping wire."

"How about adding more loading wires at the top, spaced 90 degrees apart?", asked my friend thoughtfully.

"That was tried, but it was a disaster" I answered. "The antenna became hard to match and reports fell off two to three S-units"

I handed a drawing to Pendergast. G3XAP went back to the single loading wire and came to the final conclusion that the design of fig. 5 was a practical one for the high frequency bands. The angle of slope has an effect on the signal at a long distance but the "magic" angle should be determined by experiment on each band, as the optimum angle of radiation for long distance work varies from band to band. G3XAP is still continuing experiments with this simple and effective low-band DX antenna"

"It sounds like a winner", said Pendergast thoughtfully. "It's damned hard to get any directivity on the low bands when you are restricted to a city lot. I think that G3XAP might have the answer. I hope that some readers of your *CQ* column will experiment with this interesting antenna. If enough of these semi-slopers are in action, we should find out a lot about their operating characteristics".

"Agreed", I said. "I'll be pleased to print any information I get about them in my column. And as far as that goes, if any readers have interesting photographs of their antennas, I'd like to get them, too. Everybody is interested in antennas, and it's always helpful to see what the other fellow is doing".

Note: *"Radio Communication"* is the publication of the Radio Society of Great Britain, 35 Doughty Street, London WC1N 2AE, England. Also note that W6SAI, the author of this column is the editor of the *"Beam Antenna Handbook"*, *"All About Cubical Quad Antennas"* and *"Simple, Low Cost Wire Antennas"*. All these handbooks are available from Radio Publications, Inc., Box 149, Wilton, CT 06897.

a monthly feature by

WILLIAM I. ORR, W6SAI

Antennas

Design, construction, fact, and even some fiction

Pendergast held the glass up to the late afternoon sunlight and noted the light, straw-yellow color with approval.

"This was a good year", he said happily, as he sipped the wine. "I just love these white wines from the Sonoma and Napa valleys in California . . . dry and flinty".

"Do you realize all the good DX you are missing while you are wine tasting?", I asked. Pendergast smiled and replaced his glass, picking up a second one which he sipped slowly. "Ah-h-h-a-a!", he said. "What bouquet! This one is beautiful".

I watched my friend as he slowly emptied the glass. "Wine tasting is a lot better than working DX, isn't it?"

Pendergast returned the glass to the table and said thoughtfully, "No, it isn't. It's just *different*. A nice change. I've been working so much good stuff on 10 meters these days that I can hardly believe it. Yesterday, 10 meters was open to Japan, Europe, Australia and South America all at the same time. Fantastic! And such strong signals!"

"Yes", I replied. Now that the sunspot count is rising, happy days are here again. "I haven't heard 10 meters so good for a decade! And you don't need a lot of power to work the DX."

48 Campbell Lane, Menlo Park, CA 94025.

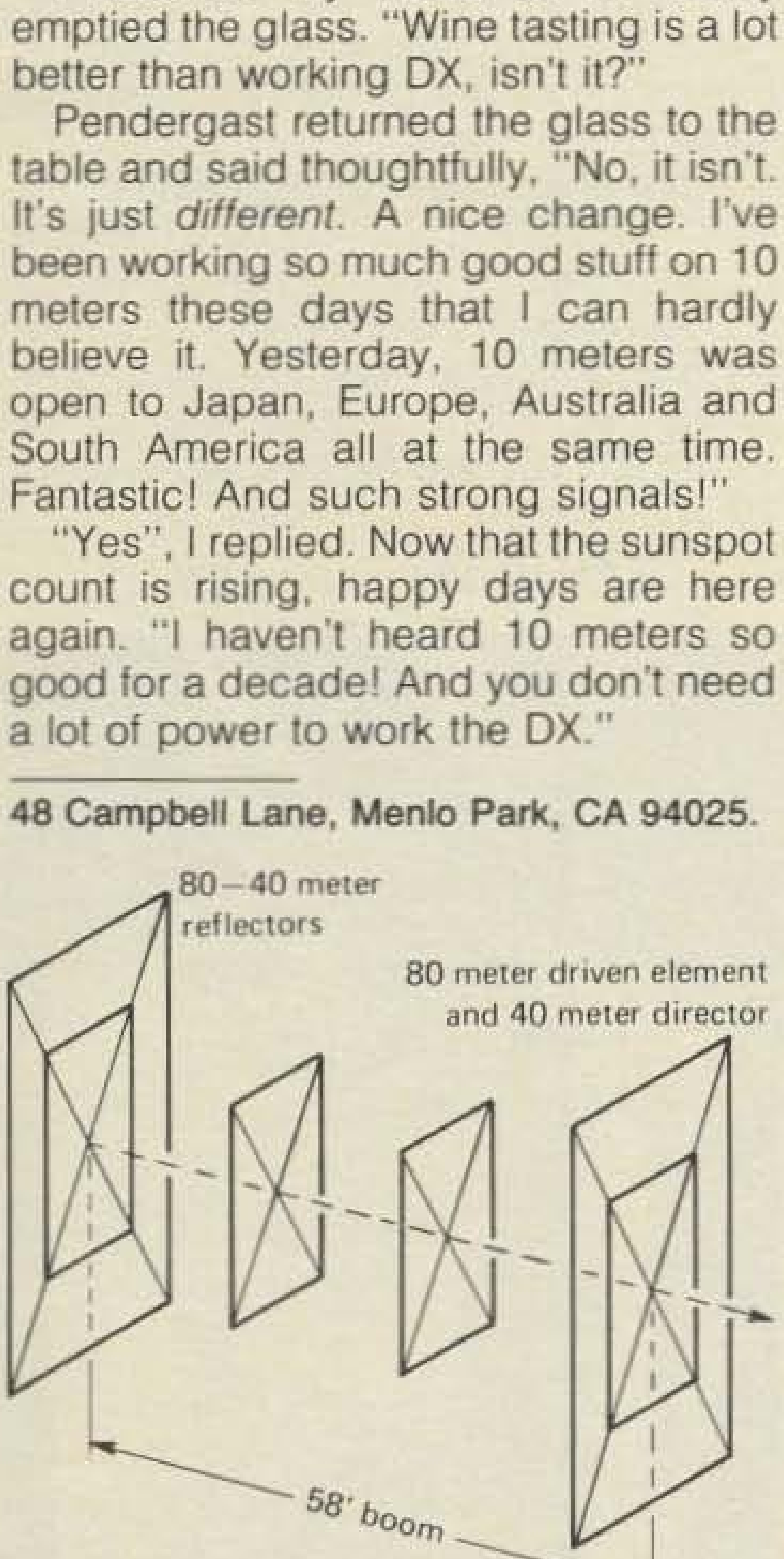


Fig. 1 — Layout of K5DUT Monster Quad. Element spacing is 19 feet. Forty meter Quad arms are 26 feet long. Quad arm for 80-40 meter reflectors is 50 feet long.

"Right", replied Pendergast. "I'm just using my transceiver and a little three element Yagi. Do you know where I got the Yagi? Well, I found a sale at one of the local CB outlets. A three element CB beam for less than twenty five dollars! You can't even buy the aluminum tubing that cheaply. So I bought it, cut about four inches off the tips of the elements and . . . *voila!* A first-class 10 meter beam! I have it up on a 30 foot high push-up t.v. mast and an inexpensive t.v. rotor. The whole works were erected in

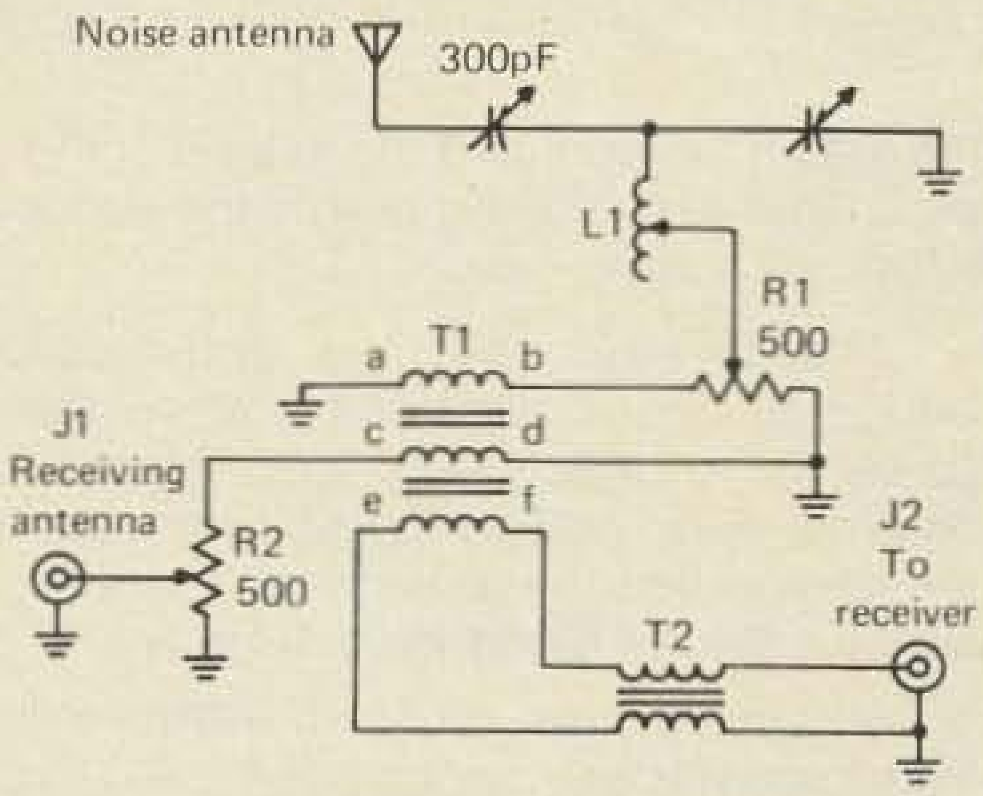


Fig. 2 — The VK3XU anti-noise bridge. Coil L1 is 50 turns, 1" diameter, 3" long with alligator clip for tap. Potentiometers are carbon type with "A" taper. See text for balun transformer data.

one afternoon in about two hours. You can't beat that for an inexpensive beam antenna!"

"Yes, there are plenty of CB antennas that can be modified for 10 meter operation. And I hear a lot of reworked CB transceivers up at the high end of 10 meters. You can work plenty of DX with a few watts of s.s.b."

Pendergast looked at his empty glass and sighed. "Well", he said slowly. "Have you gotten anything interesting in the mail?"

"Yes", I replied. "Do you remember my column in the March issue of *CQ* that featured the "Monster Quads" in McKinney, Texas? John, K5JA, sent the photos to me just to show that the amateurs in "Cow Town" (Fort Worth) had lost their title of *Quad Antenna Capitol of the World*. Well, I got a quick letter from Don, K5DUT, in "Cow Town." He says that the McKinney Quads shown in the March column really don't qualify as Monster Quads, as they aren't big enough! He says that to Qualify, the Quad has to have a boom at least 50 feet long and should have come down at least once in a bad storm! Furthermore, the 40 foot boom at K5JA is just a toy!"

"Wow!", yelled Pendergast. "What does K5DUT have up in the air?"

"According to Don, he just took down his Monster Quad. It was too small. And now he's working on a new one (fig. 1). This Monster has a 58 foot boom with four elements on 40 meters and two elements on 75 meters! He will switch the reflector element electrically to go from 3800 kHz. to 3500 kHz."

Pendergast stared at the drawing. "That baby has *fifty foot cross arms*", he gasped.

"That's right", I replied. Each 80 meter arm is made up of a center section of aluminum tubing 12 feet long, then a 10 foot section of special fiberglass tubing. The end sections are 14 foot lengths of fiberglass pole vault poles. Each section, of course, is a little longer than that because of overlap.

"The boom has a center section of 3½ inch tubing and it tapers down to 2½-inch tubing at the ends."

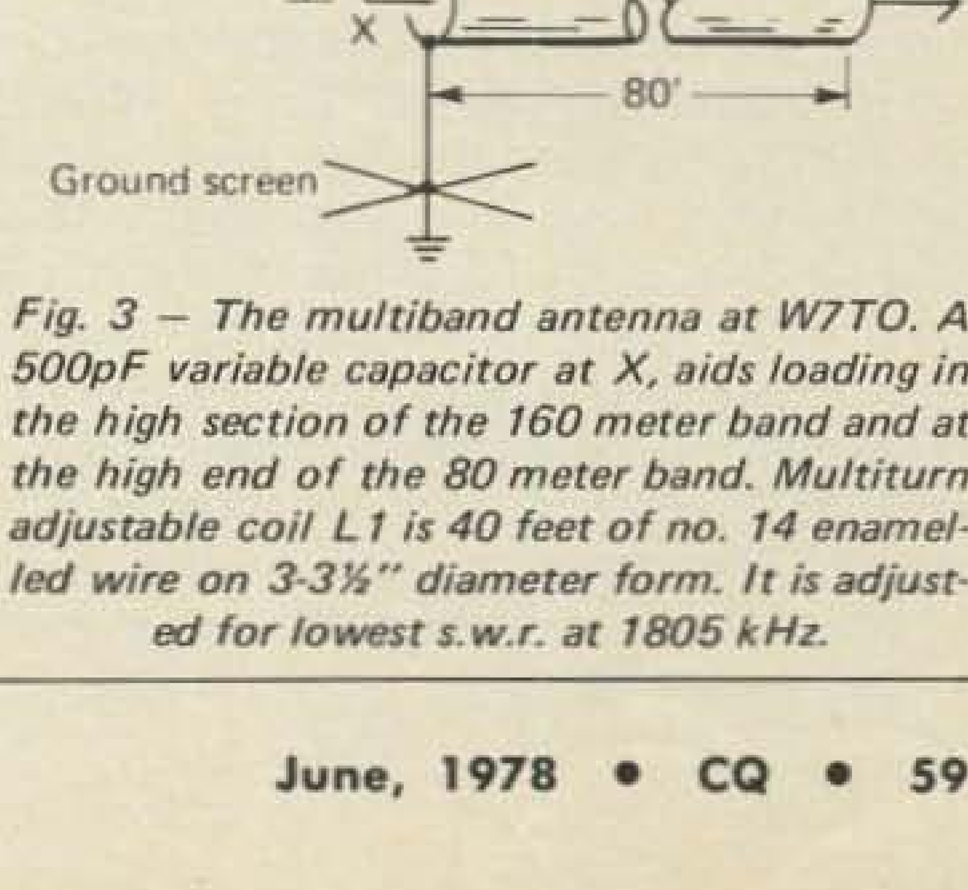


Fig. 3 — The multiband antenna at W7TO. A 500pF variable capacitor at X, aids loading in the high section of the 160 meter band and at the high end of the 80 meter band. Multiturn adjustable coil L1 is 40 feet of no. 14 enamelled wire on 3-3½" diameter form. It is adjusted for lowest s.w.r. at 1805 kHz.

"That should make a lot of noise on 80 and 40 meters when K5DUT gets it working," said my friend. "Maybe they'll hear him in McKinney, Texas!"

"This discussion of Monster Quads is pretty heady stuff", I said. "However, you can't work the DX if you can't hear it. A lot of fellows have plenty of trouble hearing the exotic signals because of power line noise which can be pretty bad if you are unfortunate enough to live near a noisy line with leaky insulators and poor hardware. You might be interested in a short dissertation on an anti-noise bridge by VK3XU which appeared in a recent issue of *Amateur Radio*, the journal of the Wireless Institute of Australia. Drew took the old idea of using a noise antenna and a phasing network and brought it up to date (fig. 2). He uses the regular station antenna, plus a special "noise" antenna which is placed near the power line to pick up the maximum amount of noise. The circuit consists of two baluns, T1 and T2. The noise antenna (a short length of wire) is tuned to resonance by the network and coupled into balun winding *b-a*. The signal plus noise from the main antenna is propagated along winding *c-d* in the opposite direction. The net field from these two windings appear in winding *e-f*. Ideally, if the noise and signal fields are equal in amplitude and phase, only the signal component appears in winding *e-f*, which is coupled to the receiver via balun T2."

"This doesn't sound like a possibility", said Pendergast.

"Right", I replied. Thus some balancing controls are required. Potentiometers R1 and R2 are for this purpose.

"The whole unit is built in a small aluminum minibox. The tuning capacitors are midget ones from a transistor radio and the coil is a section of air-wound stock. The coil tap and capacitors are adjusted for greatest noise pickup.

"The baluns are wound on small ferrite toroids about ¾-inch in outer diameter (Q2 material). They are not critical except the connections must be right. For T1, three lengths of #22 enamelled wire are wound on the core. The wires are each twenty inches long. The three wires are twisted together by clamping one end and fixing the other ends in the chuck of a hand drill. They are then twisted up about two twists per inch (not critical). When twisted, wind them around the toroid as one, keeping spacing constant as you go along. When finished, determine the matching ends with an ohmmeter and mark them. Toroid T2 is wound in a similar fashion.

When things are wired up, the noise network should be peaked for maximum noise with the main antenna potentiometer (R2) turned down for minimum input signal. Then both potentiometers are adjusted for minimum noise. Juggling the tuning network and the setting of the potentiometers should permit the noise to be attenuated.

"VK3XU says that the anti-noise bridge is especially helpful when the power line noise is very loud. He can obtain a deep null on the noise most of the time, unless the noise is coming from several places along the power line".

"An interesting device", remarked Pendergast, busy copying the circuit in his notebook. "Sometimes my power line noise just wipes me out on 40 meters".

"Noise can be a bad problem," I agreed. I picked up a letter and handed it to my friend.

"Here's a note from Dave, W7TO, describing his new multiband antenna (fig. 3). He uses this from the low end of 160 meters up through the 10 meter band with excellent results. The flat-top is about 30 feet high and is fed at one end with a vertical wire also about 30 feet long. This far end of the antenna is loaded with a coil and a 27 foot loading wire. The coil is adjusted for lowest s.w.r. on the transmission line at 1805 kHz. Under the feed point, Dave has about 400 square feet of chicken wire laid out for a ground screen. The antenna is adjusted at 3.9 mHz. by trimming the wire length a bit, just at the connection to the coaxial line. A large variable capacitor can be placed in series with the antenna wire at point *X* for adjustment, if desired."

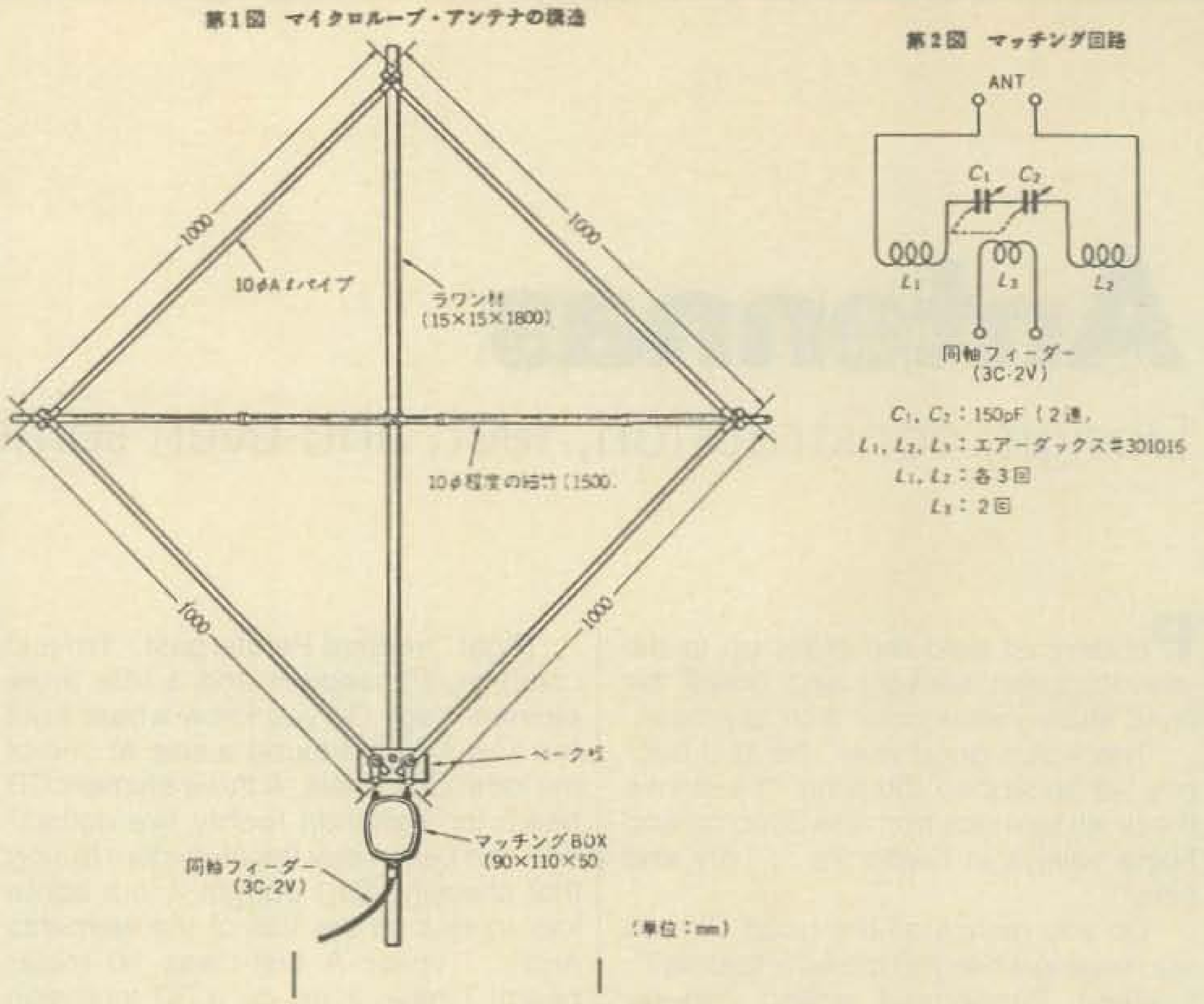


Fig. 4 – The mini-loop antenna of JG1UEA for 20 and 15 meters. Antenna is coax-fed via small tuner located in the plastic box at base of loop. See text for dimensions. (Drawing courtesy of "CQ-ham radio").

"Pretty tricky", said Pendergast. "Very few antennas function from 160 meters clear through 10 meters without some kind of tuner".

"This one seems to accomplish the task", I said. "Anyway, W7TO is having a lot of luck with it working plenty of DX".

"How about mini-antennas?", queried my friend. "There seems to be a lot of interest in small antennas. A lot of the boys can't put up a full size job, even for 20 or 15 meters".

(Continued on page 89)

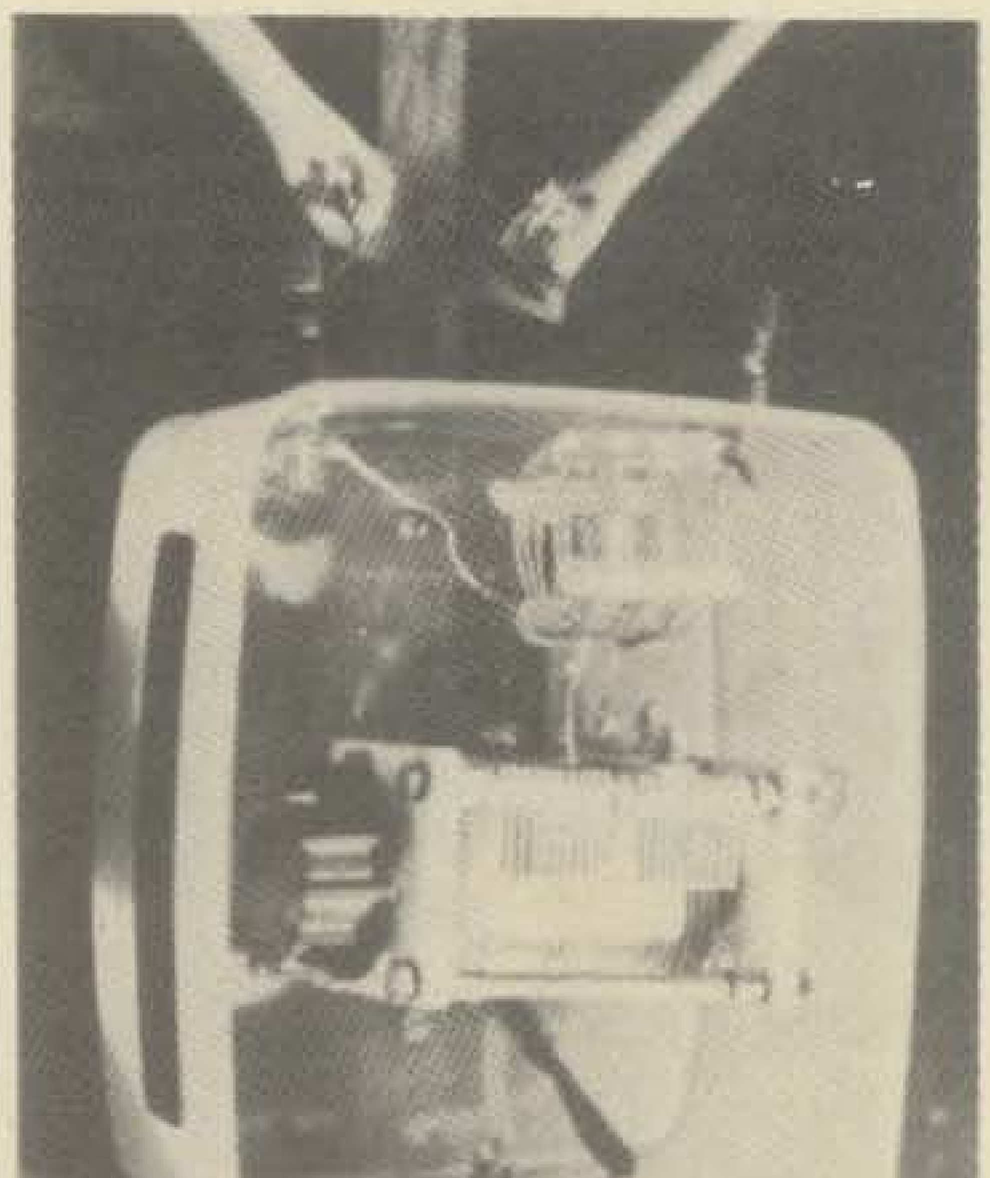


Fig. 5 – Tuning network for mini-loop antenna.

Antennas *(from page 60)*

"Well, I saw a fine article in *CQ-ham radio,* the Japanese amateur magazine a few months ago. It described a mini-loop antenna that is tunable to either 20 or 15 meters (fig. 4). What do you think of this?"

Pendergast gulped. "Well, my Japanese isn't very good. What's it all about?"

"All the dimensions are in millimeters", I replied. "It is a loop about half-wavelength in circumference for 15 meters. It is 1000 millimeters on a side, or one meter. That corresponds to 40 inches on a side. The antenna is voltage-fed at the bottom with the tuned circuit which can be adjusted from 15 to 20 meters.

"The diagonal dimensions of the loop are 60 inches. The loop is made up of four pieces of aluminum tubing about ⅜-inch in diameter. The ends of the tubing are flattened and bolted together. At the bottom feedpoint, the sections of tubing are attached to an insulating block. The cross-support arm is bamboo and the vertical support arm is wood.

"The tuning network is placed in a small box at the bottom of the loop, which is supported in a vertical position. The tuning capacitor is a split-stator job having an effective capacity of 75 pF. The three coils are made of one section of coil stock about 1¼ inches in diameter. L1 and L2 have 3 turns and L3 has 2 turns. The photo of fig. 5 should give you an idea of the network assembly.

"The capacitor is tuned for resonance either at 15 meters or 20 meters. For the 15 meter band, the operating bandwidth of the loop is about 200 kHz. and on 20 meters the bandwidth is about 100 kHz. So the little antenna should be peaked at the center of the portion of the band that you wish to use".

"What is the radiation pattern of the loop?", asked Pendergast.

"The pattern is at right angles to the plane of the loop. That is, a figure-8 pattern (similar to a dipole) in and out of the page. The builder of the antenna, JG1UEA, reports that it is better than a ground plane on 15 meters by two S-units. He has no comparison antenna for 20 meters, but has worked plenty of DX on that band".

"Looks good", said Pendergast. He paused, and then said, "Any information about treating bamboo to make it waterproof?"

"I'm glad you asked", I said. "I just got a note from VE2TH about that. Mike says that you can get an epoxy compound made by CIBA (and possibly others) called *Epoxy 502, Araldite 825 polyamide.* This resists weathering and protects the bamboo from the ultraviolet rays of the sun which tend to break down carbohydrates. He coats his bamboo with this, and while still wet, wraps the bamboo arm with fiberglass tape. He follows this up with a coat of liquid fiberglass. This makes an exceptionally strong bamboo pole for Quad construction. Finally, he puts on a final coat of fiberglass liquid with a bit of paraffin in it. This gives a glossy surface to the bamboo so that rain and ice don't tend to stick to it.

"He doesn't drill the bamboo pole for Quad wires. No, no. He makes up a sleeve which he passes over the wire at the point it crosses the bamboo. The sleeve is about six inches of polyethylene inner dielectric from a hunk of RG-8/U cable. He slips the sleeve over the Quad wire then attaches the sleeve to the bamboo pole with a wire wrap. He claims this construction has withstood the Canadian winters and winds of over 80 miles per hour!"

"Well, I doubt if you have to go into that detail with the little Japanese loop, but nothing is too sturdy for a full size Quad antenna. I hear that plenty of Quads came down this spring because of the bad weather in the east and mid-west. Perhaps the VE2TH bamboo arm treatment will help this vexing problem".

Pendergast gathered up his car keys and half-empty wine bottle.

"I must be on my way", he said. "Ten meters will open to Japan shortly and I want to be around for all the DX that will be booming in".

"Sayonara", I replied. "See you next month."

a monthly feature by

WILLIAM I. ORR, W6SAI

Antennas

Design, construction, fact, and even some fiction

"Now that DX conditions are on the rise, fellows are really getting interested in antennas", I remarked, "My mail is full of questions on the Yagi and the Quad. And some fellows are thinking about some really big beams".

Pendergast put down the stack of QSL cards he had just received from the Bureau and smiled. "Yes", he replied, "I guess a bunch of fellows had second thoughts after calling the Clipperton DX-pedition for three or four days with no resilts."

"Did you work them?", I asked.

"Certainly. The easiest contact was on 2 meters via the Oscar satellite. One call and they came right back!"

"There's going to be a lot more satellite DX as the years go on", I replied. "You had better prepare for it. And so should I", I added as an afterthought.

Pendergast tossed an envelope across the desk to me. "Here's a note from Don, K5DUT, the terror of 'Cow Town'—Fort Worth, Texas. He sent me some pictures of the antenna at VK3MO. Don swears Ian has the biggest signal from Australia. And no wonder! Look at fig. 1. This is the top four element Quad for a *stacked* Quad array! There's Ian at the 120 foot level!"

*48 Campbell Lane, Menlo Park, CA 94025

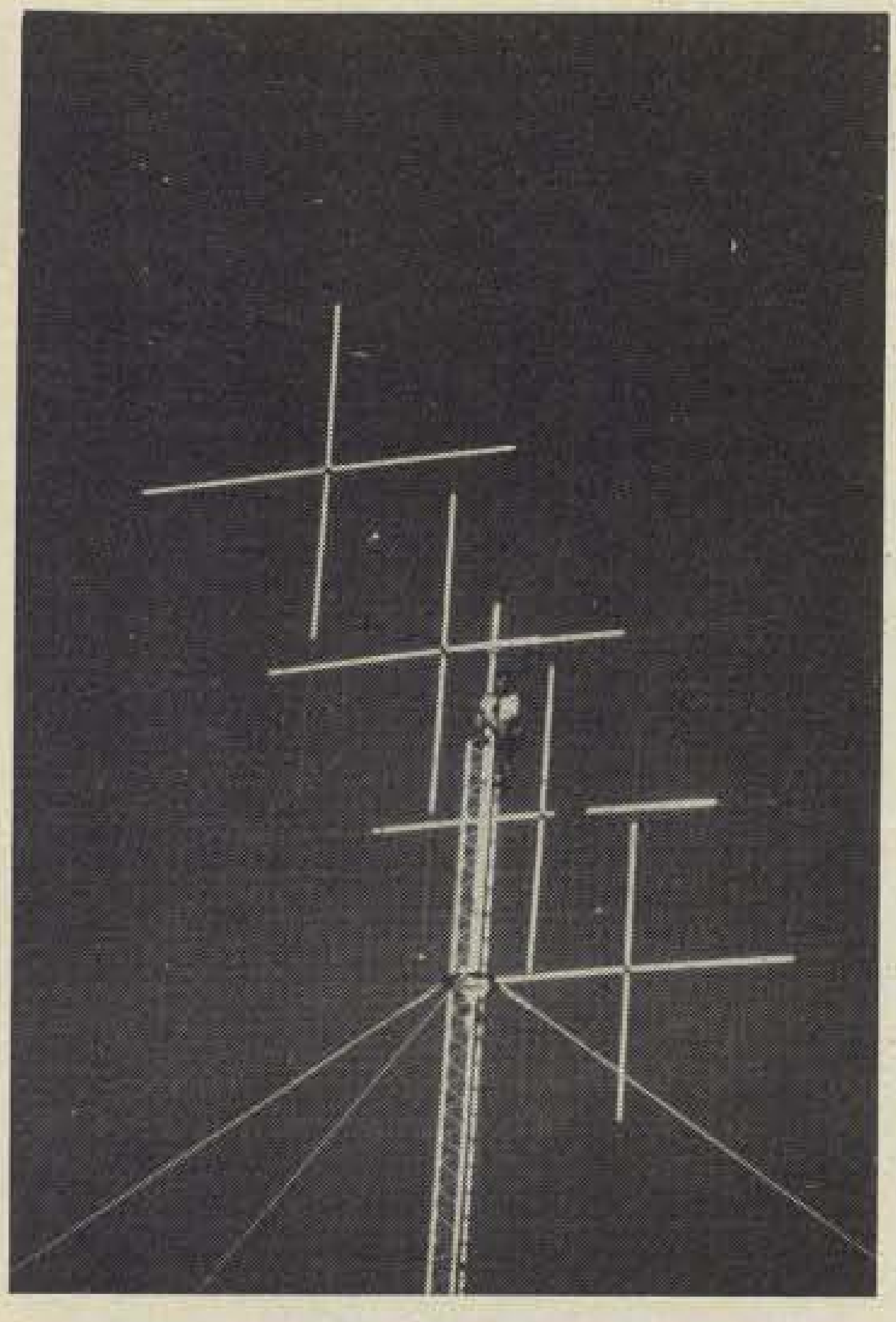


Fig. 1 – Ian, VK3MO at the 120 foot level of his tower. This is a four element stacked Quad array. The whole tower rotates in a large bearing, which is about twenty feet below where Ian is standing.

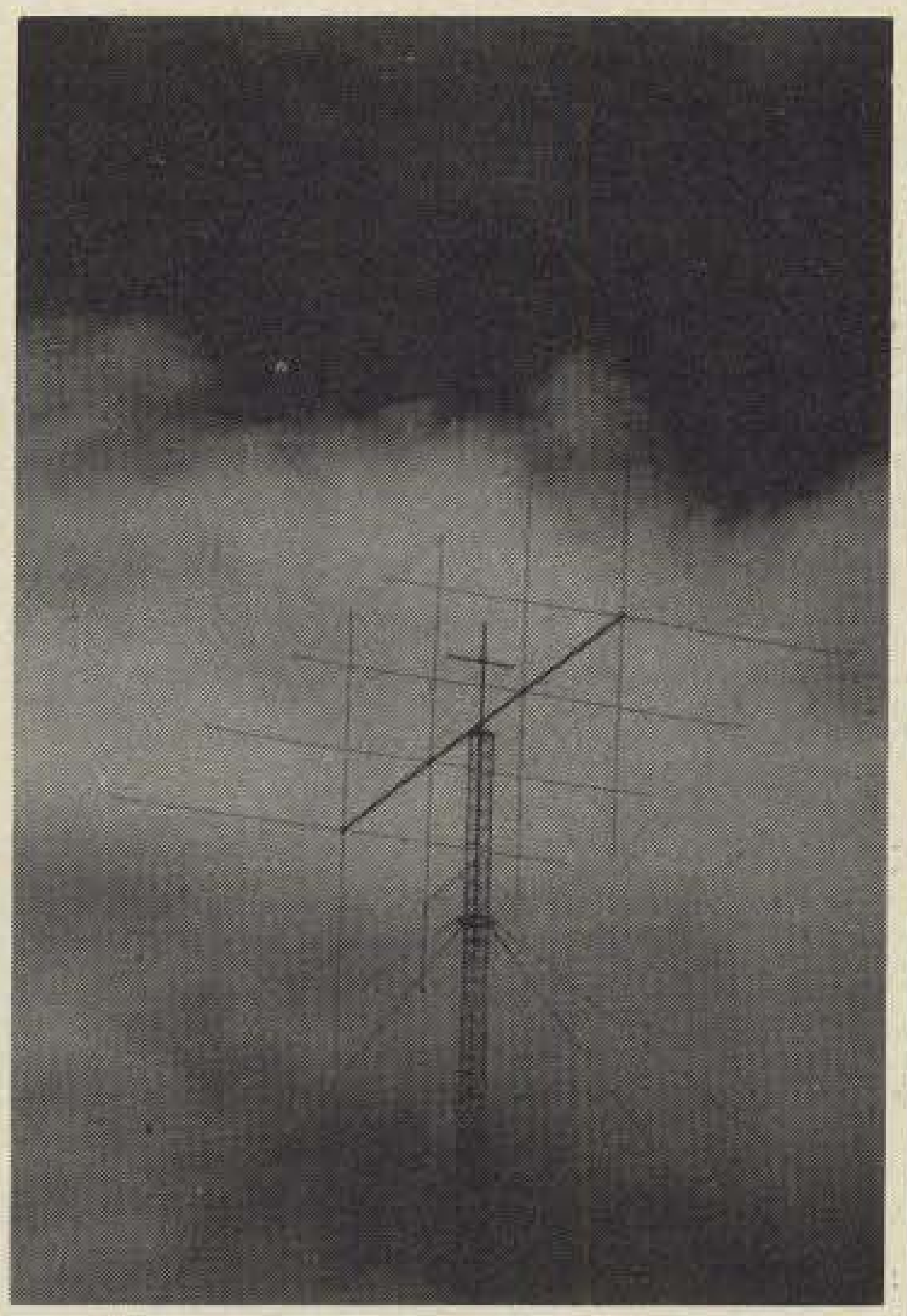


Fig. 2 – Another view of the top Quad of VK3MO's stacked array. The Quad boom is strengthened by use of top guys to a center post.

"I'd get a nosebleed if I climbed that high", I said.

Pendergast ignored the remark and handed me a second picture. "This is a second shot of the top Quad (fig. 2). Note that the Quad boom is trussed by top guys and that the tower has a slip ring about twenty feet below the Quad. That means the whole tower rotates. Everything looks ship-shape".

He handed me the last picture (fig. 3). "And here's a view of the complete array of two stacked 20 meter four element Quads. The bottom one is at 47 feet. It looks as if the rotary tower is set inside a shorter, base tower—perhaps 30 feet high. And the rotor is at ground level, right?"

"It looks that way to me", I admitted. "And Ian has a clear shot in all directions. It makes one sort of humble to see an antenna installation like that!"

With a flourish Pendergast handed me the last photograph.

"Don, K5DUT, told me that he got a chuckle out of the March, 1978 antenna column describing the K5JA Monster Quad. Don says that to qualify as a Monster Quad in 'Cow Town', the boom must be at least 50 feet long, at a minimum. Thus, the K5JA Quad is *too small* to qualify for this classification. As another example of a small Quad that doesn't qualify, Don enclosed a shot of the installation at WA5FWC. This tiny antenna (fig. 4) has two elements on 40 and four elements on 20, 15 and 10 meters. Too bad, the boom is only about 35 feet long! Finally, Don says that 'Cow Town' is the Monster Quad capitol of the World, as there are more big Quad antennas there than in any other area. And more are going up every day".

"Bet they are all CBers", I said.

Pendergast turned a slightly pink color. "I wouldn't know about that", he replied shortly.

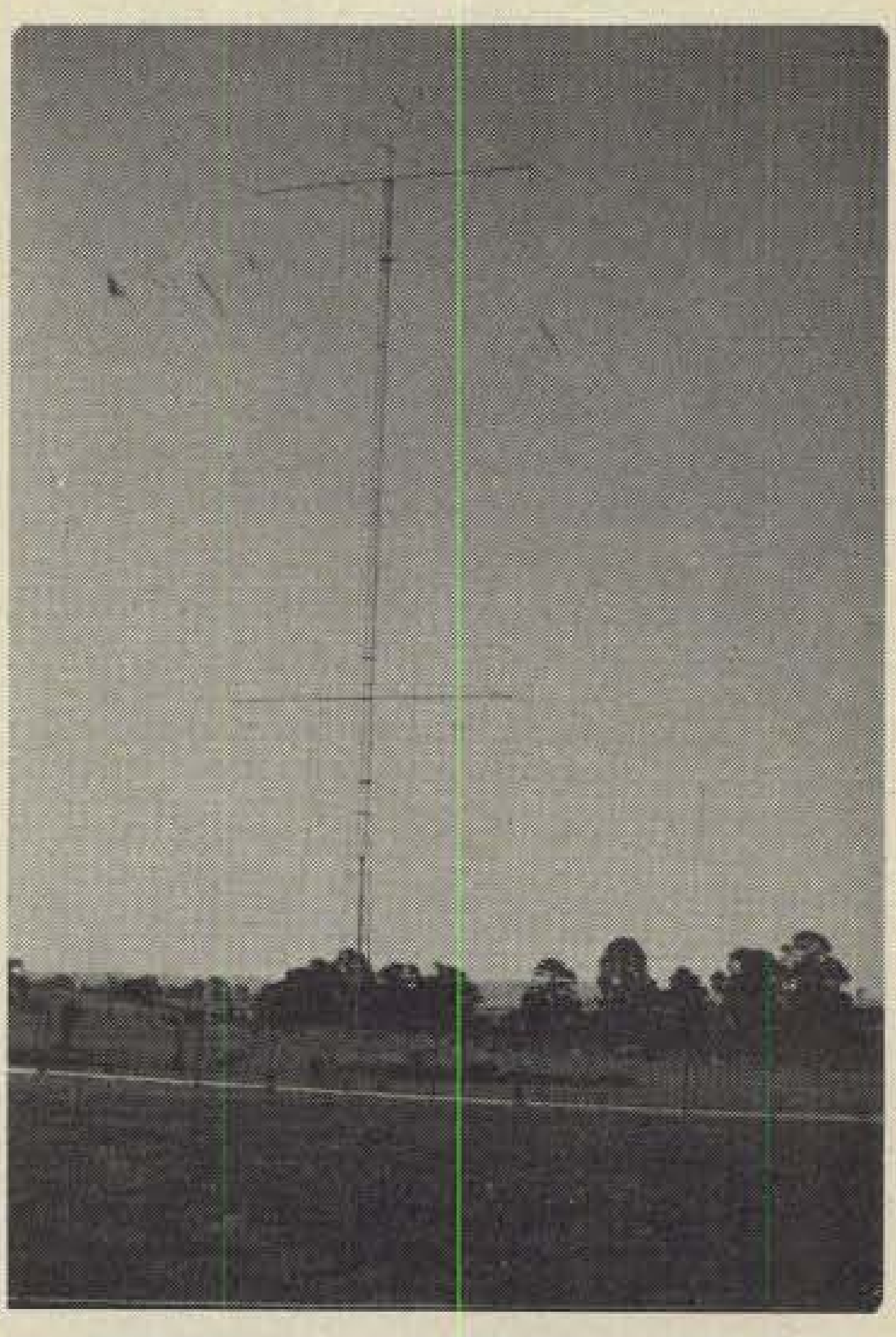


Fig. 3 – The Stacked Quad array of VK3MO built around a 120 foot, rotatable tower. The bottom Quad is 47 feet above the ground. Listen for the blockbuster of VK3MO on 20 meters.

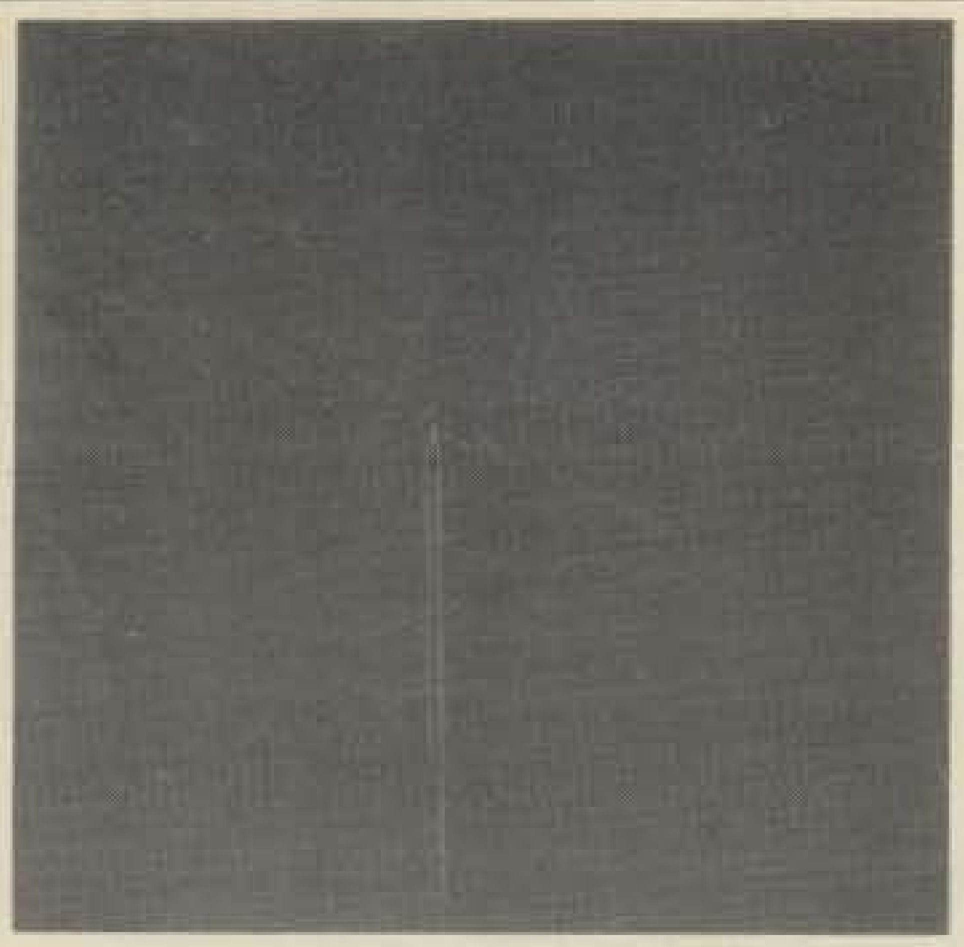


Fig. 4 – The Monster Quad at WA5FWC doesn't really qualify, as the boom is only about 35 feet long! The Antenna works on 40, 20, 15 and 10 meters with an outstanding signal.

I didn't let him off the hook that easily. "I read in *QST* a few months ago that forty-four percent of the amateurs are licensed CBers. Do you have a CB license, good Buddy?"

"Certainly", said Pendergast in a too-rapid voice. "And you do too, don't you?"

"Mine lapsed a few years ago", I said regretfully. "You know how it is".

Pendergast grinned and pulled a newspaper out of his pocket.

"Not to change the subject abruptly, but I wonder if you saw the article in *Worldradio News* recently by K6WG? It seems that he has been making gain measurements on various Quad designs. He ran his tests on 168 MHz; where one inch in wavelength is equal to one foot in wavelength at 14 MHz. Thus a direct scale (12:1) comparison in dimensions could be easily made. fig. 5 shows his gain measurements for a two element Quad. It shows that the design using a reflector provides better gain than the design with a director. Maximum gain was about 6 dB over a dipole".

"That's pretty close to my gain figure of 7 dB for a two element Quad", I remarked. I won't argue one decibel".

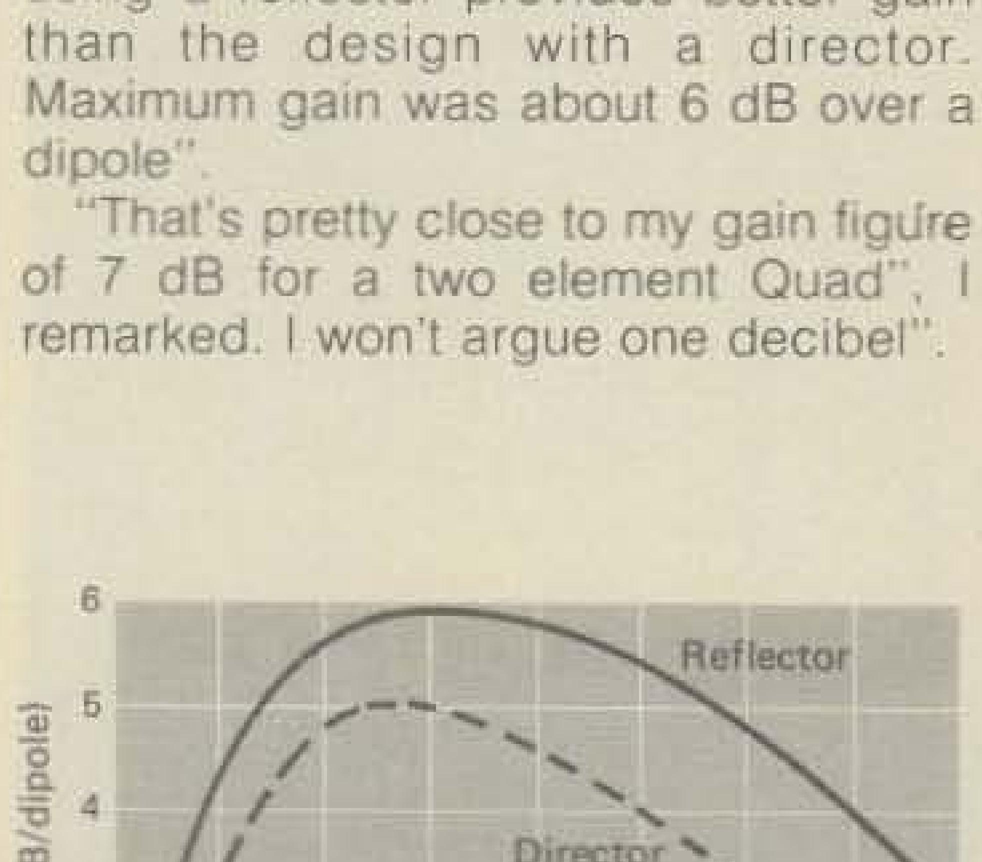


Fig. 5 – Gain measurements for a two element Quad as a factor of boom length. Reflector arrangement provides greatest gain.

"Look at fig. 6," said my friend. "That shows power gain for a three element Quad. With reflector spacing of 0.15 wavelength, forward gain peaked at about 8.5 dB over a dipole for a director spacing of 0.3 wavelength".

"Very interesting", I remarked. "That's the first time I've seen definitive gain figures for a three element Quad".

"Keith says that additional directors also show a characteristic gain peak at a spacing of 0.3 wavelength, so a four element job would have an overall boom length of 0.75 wavelength. At 20 meters, that's about 52 feet. And the gain over a dipole under these conditions is about 10 dB".

"Well, according to this data, a four element Quad for 20 meters with a 30 foot boom has a gain figure of about 9.5 dB. That seems a little low to me, but still in the ball-park", I remarked.

"Here's a summary of dimensions for the K6WG Quad design", said Pendergast (fig. 7).

"It looks like good information", I remarked. "I'm pleased to see it. And while we're on the subject of Quads, you might

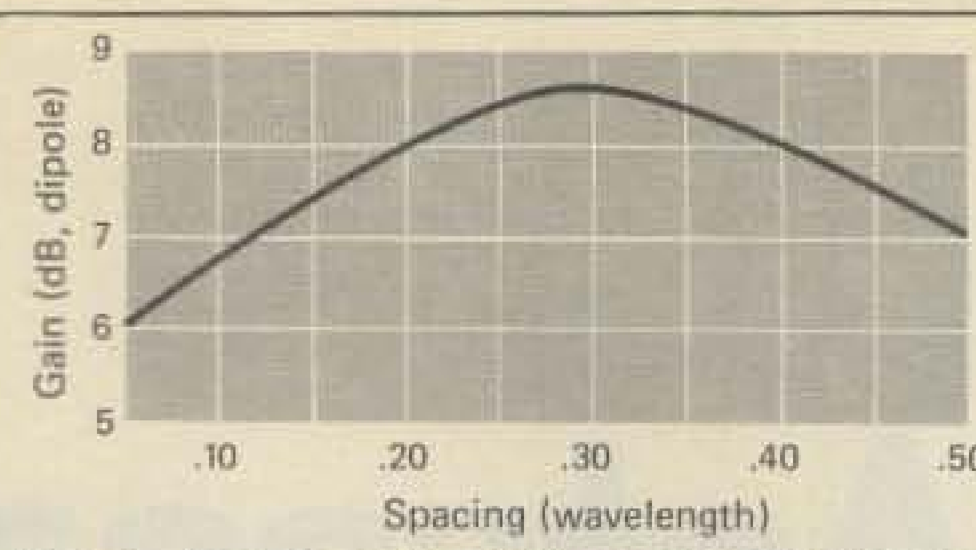


Fig. 6 – Power gain versus boom length for a three element Quad. (Data derived by K6WG.)

Pendergast. "What spacing does this array have between elements?"

"Ten inches", I replied. "That works out to about ten feet on 20 meters. So a four element Quad of this design would have a 30 foot boom. . ."

"That's right, if you merely scale up the design", remarked my friend. "However, you are cutting the number of elements down from a total of eight in one Delta Quad for 2 meters to four for a similar 20 meter design. Would the element spacing change when you drop from eight to four elements?"

"I'm not sure", I replied. "You would

BAND	DESIGN FREQ	ELEMENT LENGTH D.E.	ELEMENT LENGTH R	ELEMENT LENGTH D*	SPACING DE-R	SPACING DE-D1	SPACING D1-2-3
10	28.5	35'3"	37'0"	33'10"	5'2"	10'4"	10'4"
15	21.2	47'4"	49'9"	45'7"	7'0"	14'0"	14'0"
20	14.2	70'8"	74'3"	68'0"	10'5"	20'10"	20'10"

Fig. 7 – Antenna dimensions for K6WG's multi-element Quad design.

be interested in some data also published in *Worldradio News*. This is a Quad article by Cliff, WØMBP. It concerns the construction of a four-bay Quad for 2 meter work by WBØTEQ and himself. Fig. 8 is a good shot of Terry, WBØTEQ atop the mast, with the Quad just over his head.

"Now, the interesting point is that this is an array of Delta Quads. I can't see that there is any great difference between the operation of a Delta Quad or a Square Quad. I would think that results achieved with one could be duplicated with the other. But I'm not *sure* on that point. I've seen enough unusual things happen in the world of antennas that nothing surprises me anymore.

"In a note to me, Cliff and Terry say; 'For reasons not entirely clear, Quad elements can be effectively spaced *closer together* on a boom than Yagi elements, possibly because the Quad element is low-Q and permits closer coupling. On long boom antennas, adding elements to a Quad seems to produce less gain than adding Yagi elements, again probably due to the higher Q of Yagi elements. But the Quad-Delta design is hard to beat on a short boom antenna.' "

"This makes my head whirl", admitted

have to work that one out on an antenna measuring range".

"Well, here's the information on this Delta-Four Super Quad. Each beam is built on a six foot boom made of 1-⅞" diameter aluminum tubing. The included angle of the Delta at the boom is

Fig. 8 – A four-bay Delta Quad built by WBØTEQ and WØMBP. Terry, WBØTEQ atop the tower. A total of 32 elements in this array.

75 degrees. The V-arms are each two pieces of aluminum tubing. One is ½-inch in diameter and it telescopes into a ⅝-inch diameter length. Both pieces are 15" long. The arms are heliarced to an aluminum boom gripper made of 2-inch diameter tubing, 2 inches long, split to make an open ring that slides over the boom. It is held in position with radiator hose clamps. Number 14 wire completes the loop, attached by bolts and flat washers to holes drilled in the tubing ends.

"The Deltas are horizontally spaced 92 inches apart, with vertical stacking spaced 68 inches between upper and lower stacking booms—all spacings measured center-to-center".

I handed Pendergast a small chart (fig. 9). "These are the element dimensions. By the way, I mis-spoke. The spacing from the reflector to the driven element is 9-½ inches, not 10 inches.

"How is each antenna array driven?", asked Pendergast. He took out his laboratory notebook and prepared to copy the drawings in it.

"Each array has a gamma match on it. The match is a ½-inch diameter rod, 7 inches long, spaced ⅜-inch from the driven element. It has a ¼ inch copper rod inserted inside it. This rod is about 4 inches long and is soldered to a short wire which is in turn soldered to the center of the coaxial receptacle. The insulating material between the two tubes is a valve stem of the water closet mechanism on a toilet".

"A distinct touch", murmured Pendergast, as he sketched the design in his notebook.

"The phasing harness between the two upper or two lower Quads is 66 inches of 75 ohm *Belden 8238* coaxial line run to the "T-fitting" from each Quad, with upper and lower pairs, connected by 40 inches of the same line to the center "T" of the array".

"The whole thing sounds great", exclaimed my friend. "I'd really like to get some more information on it".

"Well, I may be wrong, but I understand if you send 50¢ to cover postage and mailing, you can get additional information on the Delta Four Quad from the Sand Hills Amateur Radio Club, Box 811, Garden City, KS 67846. It looks like a very interesting antenna design".

I pointed to the K6WG Quad material. "This is a classic case of two separate antenna investigations. Each had a different goal and used a different method of approach to the problem. And each one came up with a different answer.

"That's what makes antenna experimenting so interesting. There's not much the amateur can build these days unless he wants to go the solid-state, circuit board route. But as far as antennas go, the sky's the limit. All that is required is some space in the back yard, some wire, tubing and cable and a good s.w.r. meter. One of these days, we'll have some definitive answers as to Quad spacing and gain. The two designs shown here are a good step in the right direction".

Element	Rod	Rod
Reflector	25¼"	25¼"
Driven	24¼"	24¼"
Dir. #1	23⁹⁄₁₆"	23⁹⁄₁₆"
Dir. #2	23½"	23½"
Dir. #3	23½"	23½"
Dir. #4	23⁷⁄₁₆"	23⁷⁄₁₆"
Dir. #5	23⅜"	23⅜"
Dir. #6	23⅜"	23⅜"
Wire	**Space**	**Total**
31½"	1"	83"
30½"	1"	80"
39⅝"	1"	77¾"
29⅝"	1"	77⅝"
29½"	1"	77½"
29½"	1"	77⅜"
29½"	1"	77¼"
29⅜"	1"	77⅛"

Fig. 9 – Element dimensions for the 2 meter Delta Quad array.

a monthly feature by

WILLIAM I. ORR, W6SAI

Antennas

Design, construction, fact, and even some fiction

Pendergast opened the door to the refrigerator and removed a *Life Support System*. He expertly popped the lid and took a long , refreshing drink from the frosty can.

"Ah!", he said. "Just the thing for these hot days!"

"Since when have you been drinking *Rocky Mountain Cool-Aid*?", I asked enjoying the broad smile on his face.

"Any port in a storm", he replied. "That's all you had in the box. Regardless of the name, it tastes *great* when its free!"

"Have another one", I responded." I'm on a diet. And we still have a pile of letters to read that arrived during my vacation".

Pendergast reached out and speared a letter with a screwdriver blade. "All right", he said, "Here's the first one. And it is from Don, K5DUT, in Fort Worth, Texas. Don says that activity is at an all-time high in "Cow Town." Bob, W5MOK, has put up a seven element Quad on a 62 foot long boom. And Luke W5VGE, is running experiments on an *eight element Quad* on a 58 foot boom.

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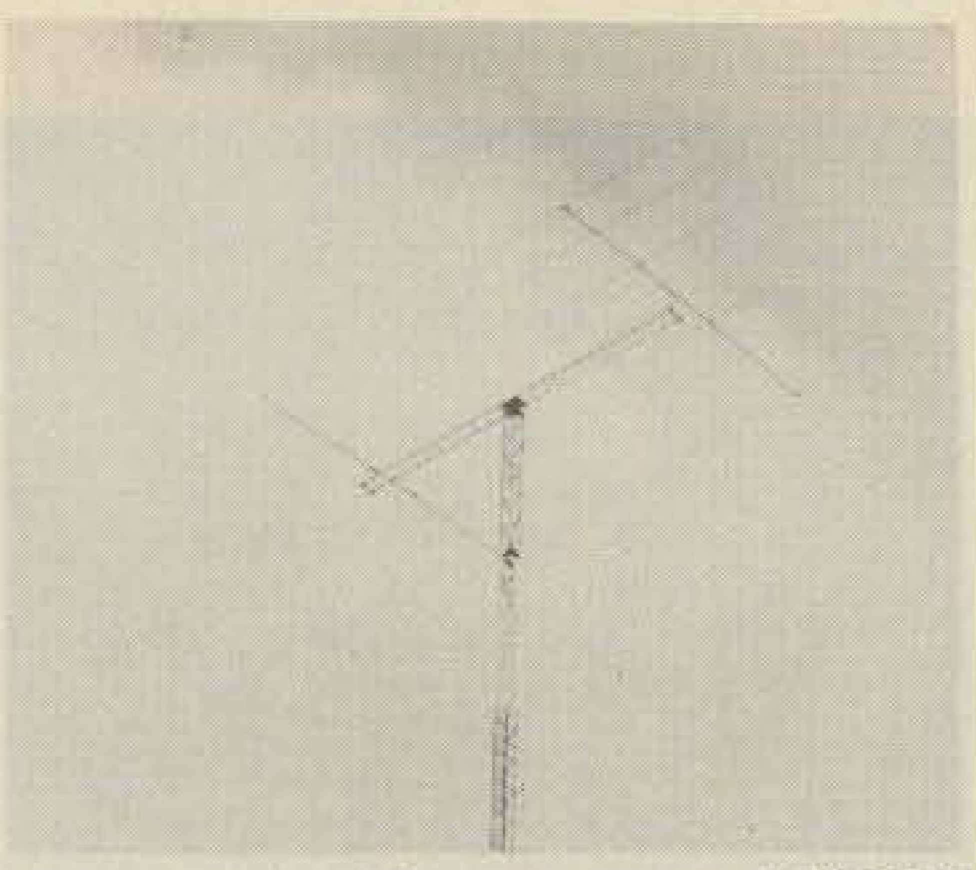

Fig. 1 – The block-buster antenna at KP4RF. It consists of two five element Yagi beams, collinear, with 55 foot spacing between the booms. The antenna is 155 feet in the air, atop a 3,000 foot high hill in Puerto Rico. Anybody working Pedro can attest to the remarkable signal from this fine antenna.

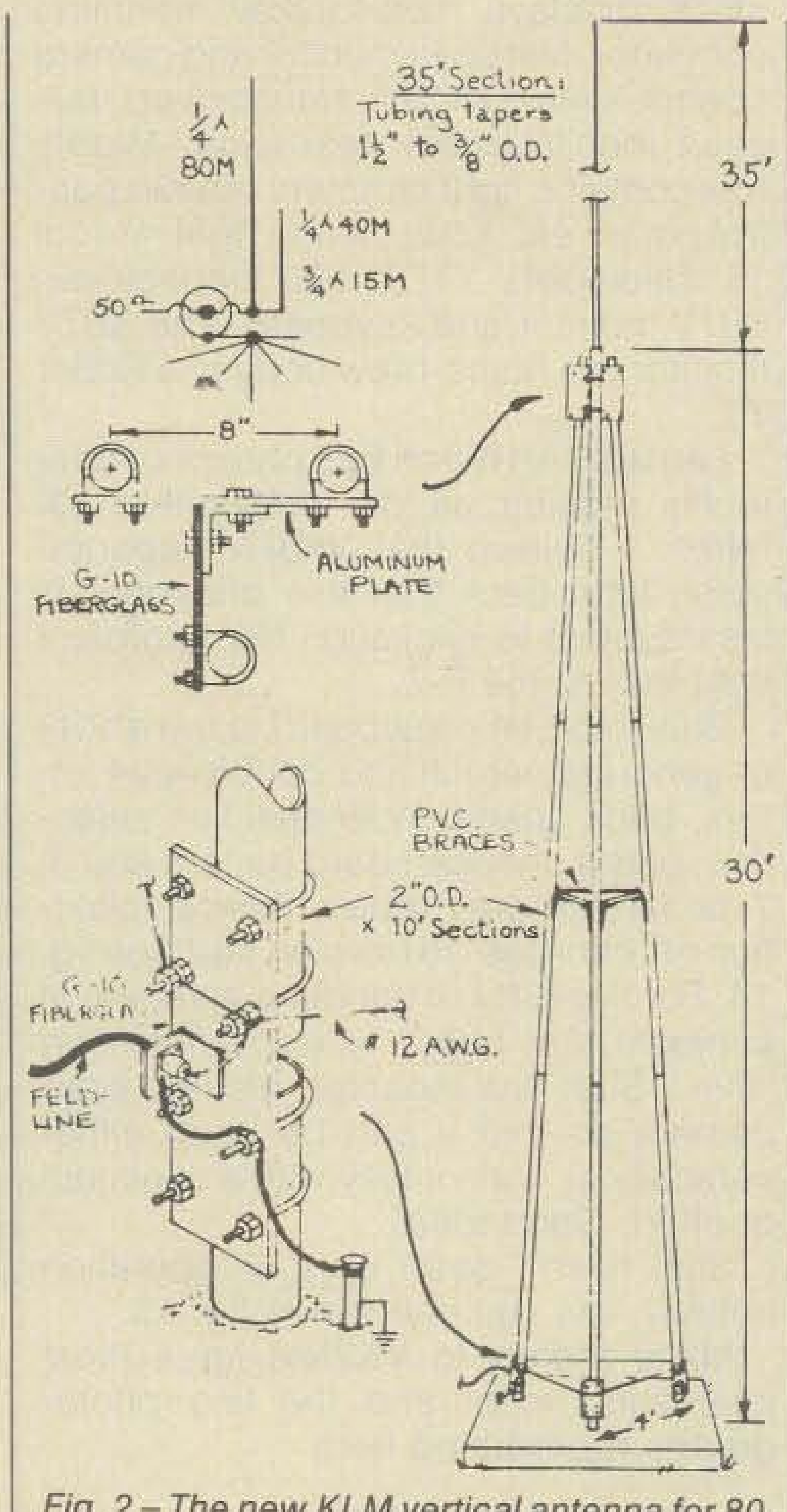

Fig. 2 – The new KLM vertical antenna for 80, 40 and 15 meters features broadband response. Antenna is freestanding and requires only a modest base to support it.

And he's planning to put *eleven elements* on 10 meters on the same boom. Hmm-m-m! No wonder Don calls Fort Worth the Monster Quad Capital of the world!"

"Well, I must admit they have a lot going for them. However, they aren't the only peanuts on the shelf. When I was in Hawaii last spring I heard the fantastic signal of Pedro, KP4RF, in Puerto Rico.

"Japan is a pretty tough place to work from Puerto Rico, but KP4RF had a tremendous pile-up of JA stations calling him. I ran across the pile-up by accident and it sounded like a beehive, and it was pinning the meter of my receiver. Then KP4RF came on with his block-buster antenna and really blew the frequency clean! A very impressive antenna (fig. 1).

"It is composed of two five element Yagi beams, collinear, with 55 feet spacing between the booms. The antenna is 155 feet high in the air, atop a 3,000 foot high hill near the sea".

"How much gain would KP4RF get from a big beam like that?", asked my friend as he sipped his brew.

"Well, I would guess each beam provides a power gain of about 10.5 decibels over a dipole. And Pedro probably picks up about 2.5 decibels from the stacking arrangement. That makes the total power gain about 13 decibels over a dipole. And that's a *lot* of gain on 20 meters. Add the excellent location to it. . . ."

"And don't forget the KP4 call, too", exclaimed Pendergast. "A KP4 call is worth at least six decibels in a pile-up. Maybe more".

I reached over and took a quick drink from Pendergast's can.

"Right", I said." The signal report increases with the rarity of the DX call. A new country, with a signal just out of the noise level rates at least an S-8 report-possibly S-9. And, of course, no DX station worth his QSL card ever gets worse than an S-7, regardless of how loud he really is".

"True", admitted Pendergast, as he picked up the next letter. "But KP4RF and the boys in "Cow Town" are going to have to watch out. Here's a note from Frank, W6KPC. And Frank is putting up the ultimate block-buster for 20 meters, I'm sure. Imagine a 200 foot self-supporting tower, with the top 100 feet rotatable. And imagine two six element be collinear, at the top. Pretty much like the arrangement that Pedro, KP4RF, has. And imagine two more six element beams at the 100 foot level—all four beams supported by the rotatable section of the tower! That makes 24 elements on 20 meters! That should be good for a power gain of at least 16 to 17 decibels! Wow! It shatters the mind!"

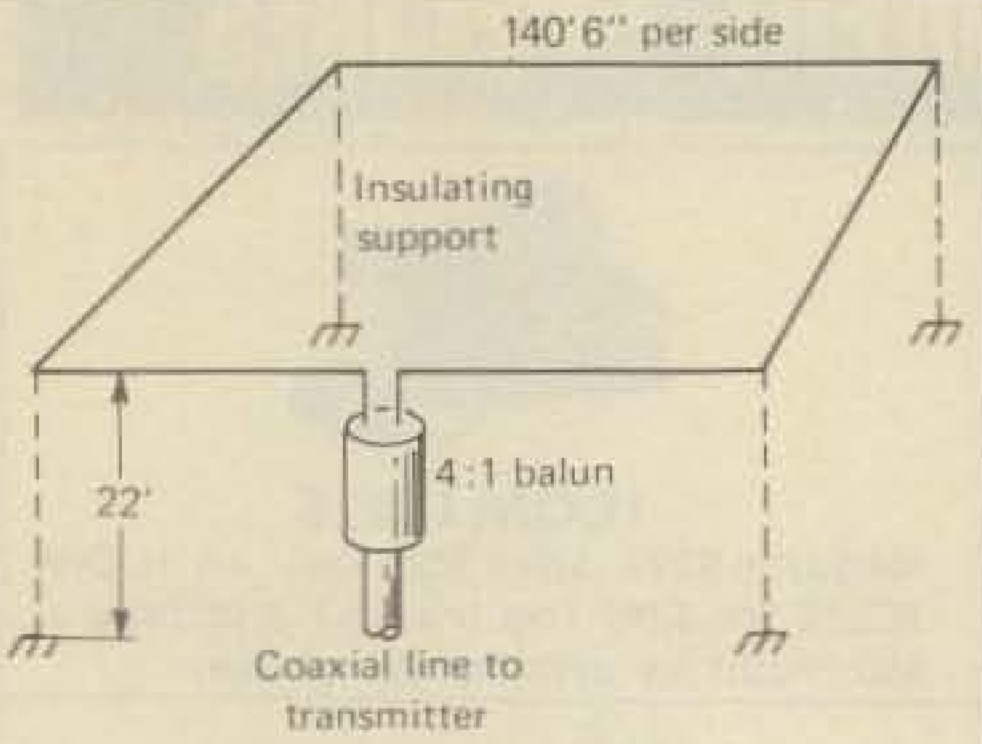

Fig. 3 – The "Merry-Go-Round" Quad loop of W9LZX. Only 140 feet on a side, the antenna works on all bands, 80 through 10 meters. Antenna is fed with a 4-to-1 balun and a coaxial line.

"I hope to get some pictures of this beast", I admitted. "Surely it must be the winner in the race for domination of the frequency on 20 meters".

"Let's come back down to earth", suggested Pendergast. "Sure, it's a lot of fun to talk about big beams, but what about the fella on a city lot? With little cash in his pocket? What does he do about it?"

"There is plenty of DX to be worked with a dipole or a ground plane", I replied. "The ionosphere is a great leveler of signals. The fellow with a modest antenna may not be first in line when the new country comes on the air, but he seems to get there just the same".

"Yes", replied Pendergast. "The Clipperton Island gang worked over twelve thousand stations, and I'm sure not all of them had monster beams".

"Still up-tight because you didn't work Clipperton?", I asked.

Pendergast smiled. "Yes, but not so much now. Time heals all wounds, and I'm sure that somebody will go there again in the next 20 years. So, all I can say is wait until next time".

"That's a good mental attitude", I replied. "But, just the same, you are right. The ionosphere can lend a helping hand to the QRP DKer, or the DXer with a modest antenna. A few weeks ago I pulled out all my foreign QSL cards and looked them over. Almost 60 percent of the foreign DX stations used ground plane antennas. And some of those signals were *loud!* So don't look down your nose at the vertical antenna".

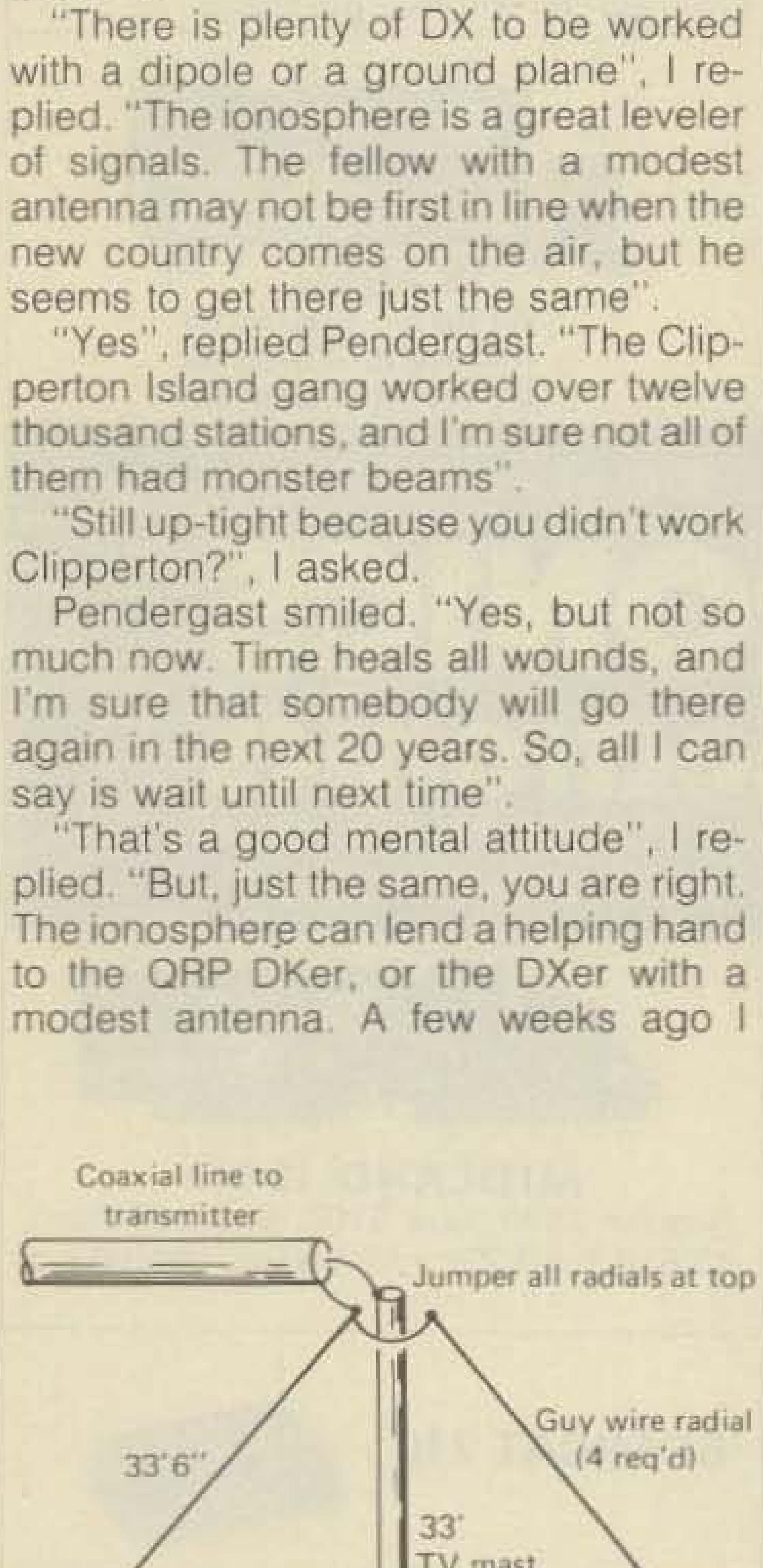

Fig. 4 – The K6WG "inverted vertical" antenna for 40 or 80 meters is an upside down ground plane, fed at the apex.

I reached in the drawer at the operating desk and brought out a drawing (fig. 2). "Here's a very interesting vertical antenna designed for operation on 80, 40 and 15 meters. It is freestanding, has very low wind resistance and requires only a modest base to support it.

"Bandwidth is excellent. Eighty meter coverage from 3.8 MHz. to 4.0 MHz. is achieved with an s.w.r. of less than 1.5-to-1. And on 40 meters, the whole band is covered with an s.w.r. of less than 1.8-to-1. And on 15 meters, the whole band is covered with an s.w.r. of less than 1.5-to-1. Now, that's good news for the fellows using solid-state amplifiers which are very sensitive to the s.w.r. of the antenna circuit.

"Basically, the antenna is composed of two separate verticals: one for 80 meters and one for 40 and 15 meters. The physical arrangement of the tower legs makes for a rather wideband affair. Ultimate operation, of course, is determined by the radial system. A minimum of three radials for each band is suggested. This particular antenna (a prototype) uses three 80 meter radials and nine 40 meter radials. An additional six radials were used for 15 meters".

"Interesting", remarked my friend. "What is the construction of this antenna. And who makes it?"

"Two-inch irrigation tubing is used for the lower portion of the antenna—the tower", I explained. "The top section is made of telescoping tubing, 1-½ inches down to ⅜ inch at the tip. The prototype used surplus G-10 fiberglass material as an insulator. The center insulator should be high quality as rather high r.f. voltage exists at this point. The base insulator isn't so critical. And, for your information, the antenna will be marketed by *KLM Electronics*, I believe".

"It looks like a great antenna for the fella with restricted space", remarked Pendergast, as he made a drawing of the antenna in his notebook.

"Here's another interesting antenna", I remarked. "My old friend, Clarence Moore, W9LZX, the inventor of the Quad antenna is at it again (fig. 3). He calls this his "Merry-Go-Round" Quad. Basically, it is a very large, horizontal Quad loop measuring 562 feet in circumference. That amounts to 140 feet six inches on a side. The wire is parallel to the surface of the ground and about 22 feet in the air. It is fed in the middle of one side with a coaxial line.

"Because of the relatively large size of the loop, the antenna has a broadband response that is very useful. The s.w.r. on 80 meters is about 1.4-to-1 at 3.5 MHz., rising to about 2-to-1 at 4.0 MHz. And on 40, 20, 15 and 10 meters the s.w.r. is less than 1.5-to-1 across the whole band. Clarence is working on a simple network to make the antenna work on 160 meters, too. Right now, with these dimensions it is resonant at 1787 kHz., which is a little low for anything except the low end of the 160 meter band".

"This looks like the universal, all-band antenna", remarked Pendergast. "Is there any useful information about directivity?"

"Too early to tell", I replied. "It has only been up for a short time, but W9LZX reports good results, on working casual DX on all bands. Hopefully, we'll know more as time goes on. It is a very simple antenna to erect.

"The antenna is fed with a 4-to-1 balun. And that's all there is to it", I concluded.

"Have you seen the simple antenna that Keith, K6WG, is using on 40 meters?", asked Pendergast as he drew a sketch in my log book (fig. 4). Keith has done a lot of experimental antenna work and he has found this "inverted vertical" antenna to work well for either 80 or 40 meters. Basically, it is an upside-down ground plane. The radial system is a half-wavelength long tip-to-tip, which you can look at as two (or more) one-quarter wave radials. The radiator is a quarter-wave wire that drops down from the center of the radials. It is fed at the top.

"The antenna is built around a 33-foot TV slip-up mast. The mast is guyed by four wires, which are the radials. Each radial is a quarter-wavelength long. The feedline is taped to, and runs up one of the radial wires. The center conductor connects to the vertical section and the outer braid of the line is attached to the radials. So you see, it is an inverted ground plane, with the high current portion of the antenna at the top of the vertical wire, instead of at the bottom."

"That should reduce ground losses", I admitted. "It looks like a good idea. I had a version of this idea once. It used two radials, in a line, and the vertical antenna was dropped down from the center point. I was in an apartment at the time and strung a half-wave wire across the building and then dropped the quarter-wave wire down at the center. I ran the coax cable out to the center point. The vertical radiator was actually below me, as it almost reached to the ground. But it worked fine; there's no law that says the ground plane has to be right-side up, or upside-down!"

Interesting antennas such as these (and others) are described in W6SAI's handbook: *Simple Low-Cost Wire Antennas*, available for $4.95 plus 50¢ postage from: Radio Publications, Inc., Box 149, Wilton, CT 06897.

a monthly feature by

WILLIAM I. ORR, W6SAI

Antennas

Design, construction, fact, and even some fiction

"Well, laddie-buck, you certainly seemed pleased with yourself these days", I remarked. Pendergast hummed happily to himself as he settled down in his purple imitation lamb's wool operating chair and removed the imported *tru-stereo* earphones from his head. He draped the earphones carelessly over the edge of the table and calmly watched as they slipped to the floor with a clatter. He yawned luxuriously and then said, "Yes. What fun to have ten meters open for DX once again! Have you been listening in these past few days?"

"I certainly have", I replied. "The sunspot cycle is well on its way up by now".

"What do you think the maximum value will be?", Pendergast inquired anxiously, a slight frown sweeping across his handsome features. "Last I heard the prognostication was for the cycle to peak out about 55 or 60".

"No way", I said. "It is passing that estimate right now. From what I read in the tea leaves, I would think that it will peak out at about 150. That makes it just about an average cycle".

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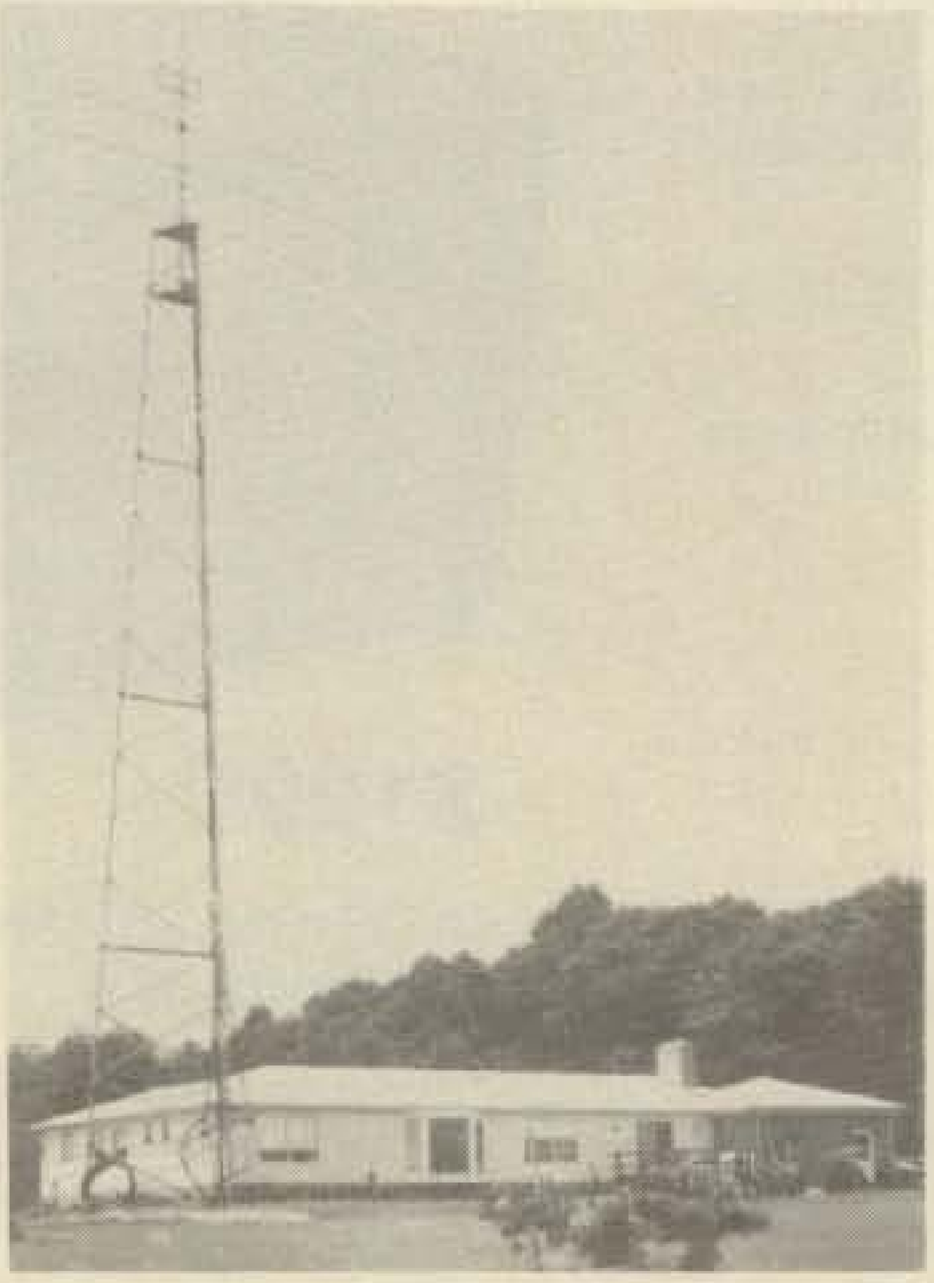

Fig. 2 — The "antenna farm" at K3WX. Tony has a modest 160 foot tower at the side of his house which supports antennas for all bands between 80 meters and 2 meters. There are stacked 20, 15 and 10 meter beams in this view, plus assorted v.h.f. antennas atop the structure.

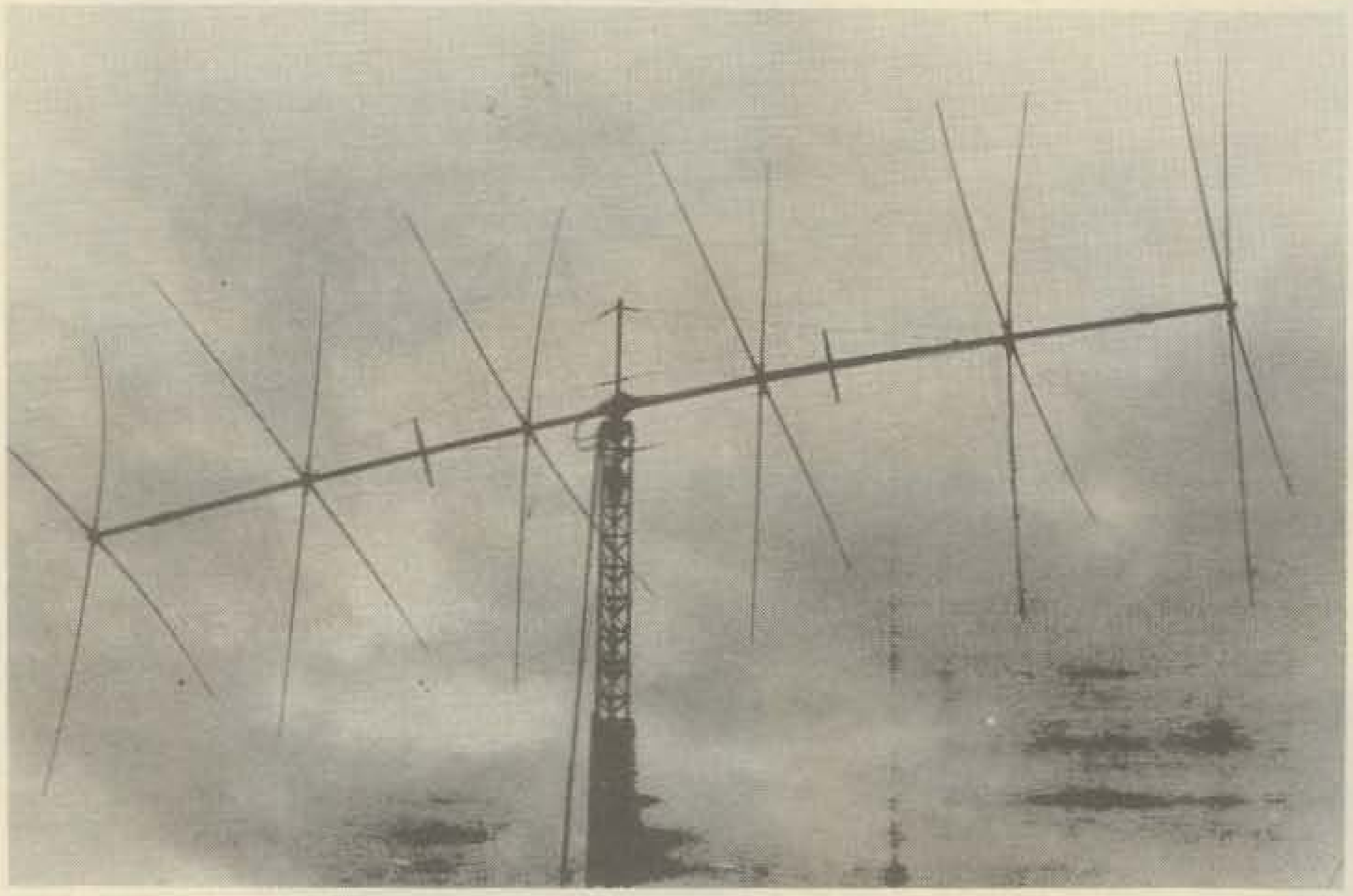

Fig. 1 — The block-buster six element 20 meter Quad of W6MMA. Vern's quad is based upon the design of K6WG which was discussed in the July antenna column. Does the antenna work? You betcha!

"One-fifty", breathed Pendergast. "That sounds like 10 meters will be good for another five or six years!!"

"At least", I replied. "There should be a lot of action on that band this winter. Are you going to join in the fun?"

"I don't know", admitted my friend. "I don't have a good 10 meter beam at this time". He hesitated. "Any suggestions?"

"Yes", I replied. "The quickest and easiest—and cheapest—way to get on 10 meters is to buy a three element Yagi for CB. You can get a real bargain in a three element CB antenna at many of the franchised CB stores. Then to move it in frequency from the 11 meter band to the 10 meter band you merely trim six inches off the tip of each element".

"You mean, the overall length of each element will be a foot shorter than normal?", asked Pendergast as he reached for his ever-present notebook.

"That's right. That will drop the center frequency of the antenna to about 28.7 MHz and you'll get good beam performance from 28.0 MHz up to about 29.4 MHz. Don't worry about changing the spacing, or the matching system. Just trim the elements and you are in good shape. You can't beat that for a quick start on 10 meters".

Pendergast put his notebook aside and reached for a small pile of letters on the operating table. "Let's look over the mail-bag", he said. "The first letter is from Vern, W6MMA. He encloses a snapshot of his *six element* Quad built on the K6WG design that was discussed in the July column (fig. 1). This 20 meter Quad is a *real* monster. Notice that the boom is double-guyed, that is it has a set of top guys, plus a set of intermediate guys on each side of the boom."

"A good idea," I said. "Most amateurs tend to underestimate the force of the wind and you can get into trouble fast with a big Quad on a windy day. And how does it work? Well, just listen to W6MMA in a DX pile-up."

"That antenna should give the gang in 'Cow-Town' an inferiority complex. By the way, what have you heard from those Quad-builders K5DUT and K5JA?"

"Not much," I admitted. "I guess Don and John are too busy working DX to waste time letter writing."

Pendergast pulled a bulky envelope

out of the pile. "What's this?" he queried.

I looked at the photographs. "That's the antenna farm at K3WX, Tony. How do you like it? Fig. 2 shows the general situation. Tony has a 160 foot tower at the side of his house. There are stacked 20, 15 and 10 meter beams atop, plus assorted v.h.f. antennas. Here's a closeup of the top of the tower (fig. 3) and another snap showing Tony climbing the ladder that runs to the top of the tower. And look at fig. 4! He's got an inverted-V for 40 meters on the end of the 20 meter beam and also an 80 meter, 2 element log-periodic beam strapped on at the 85 foot level!"

"That 80 meter beam looks interesting," remarked Pendergast as he studied the photographs carefully (fig. 5).

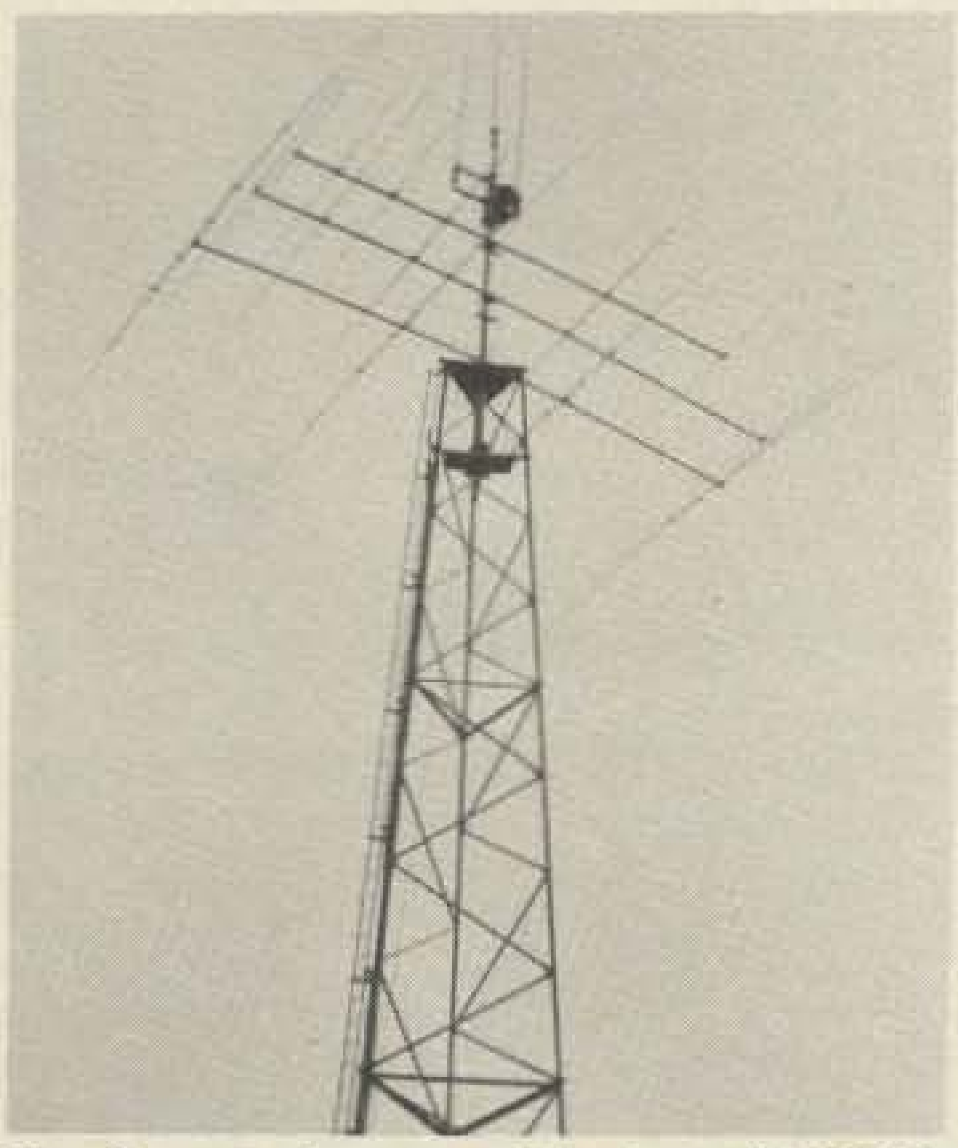

Fig. 3 — A closeup of the top of K3WX's tower. Note the ladder running up the side. Need exercise? How about a sprint up to the 160 foot platform? It looks as if there antennas for 6, 2 and 450 MHz at the tippy-top of the rotating mast. The rotator is on a platform a few feet below the top of the mast.

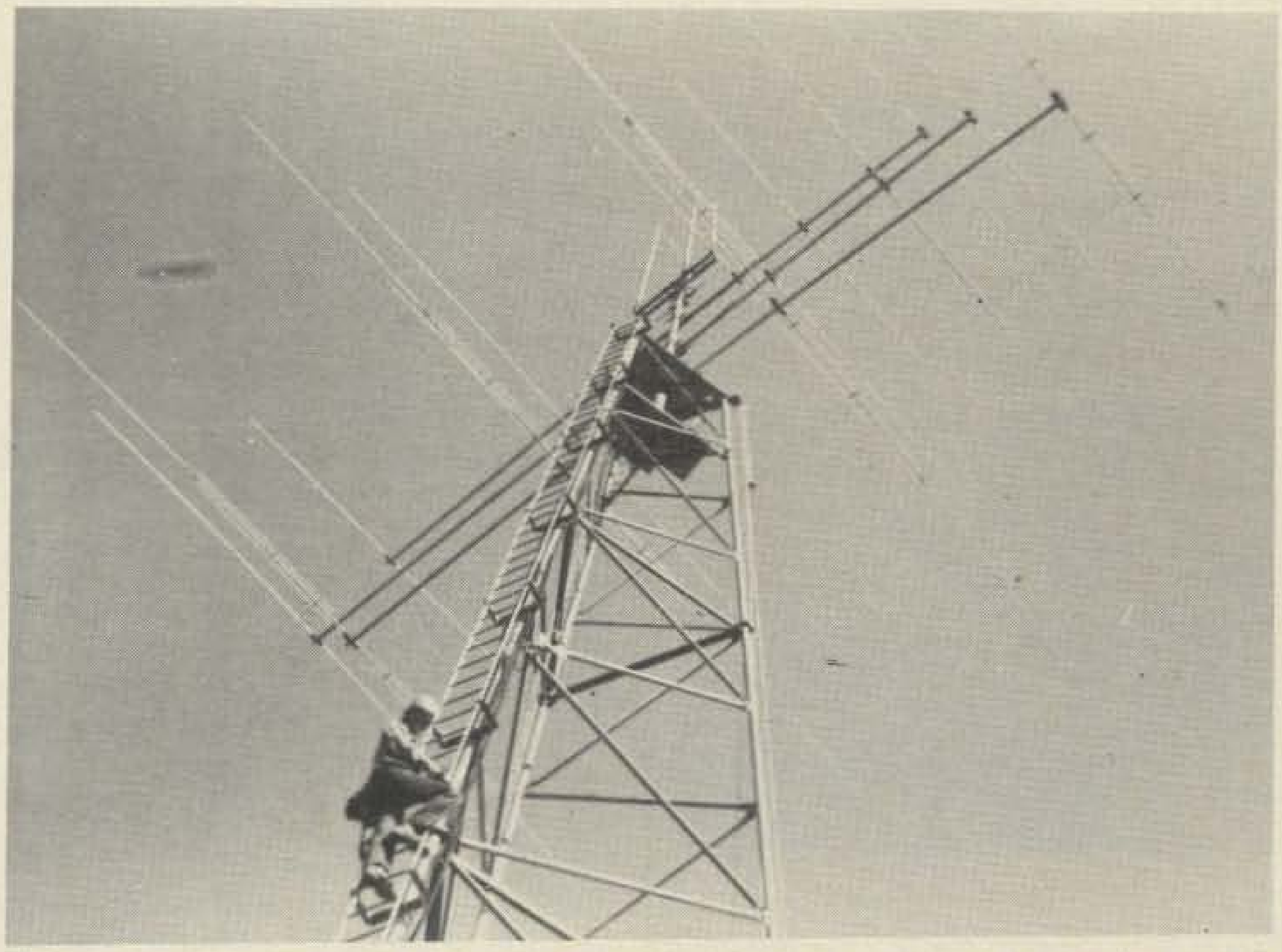

Fig. 4 — Here's K3WX on his way to the top. I'd get a nosebleed if I went that high! It pays to be young.

Fig. 5 — Another view of the K3WX antenna system. In this view Tony has added an inverted-V for 40 meters at the end of the 20 meter boom, plus a two element log-periodic antenna at the 85 foot level for 80 meters.

"Agreed. You can't tell from the picture, but the elements are loaded to reduce overall length," I replied. "Look at fig. 6. This is a shot of the end of one element showing the tapered winding on the fiberglass pole.

"And here's a picture of the 80 meter element mounting plate (fig. 7). You can see the center point of one of the elements. Looks like quite a project, doesn't it?".

Pendergast frowned. I wonder how Tony copes with rust and corrosion with all that aluminum up in the air?"

"He uses a compound especially prepared for aluminum-to-aluminum or aluminum-to-copper joints (fig. 8). It's called *NOALOX*. It comes in a plastic bottle and you just smear some of the good on the mating pieces of metal before the joint is assembled. Tony picked it up in his local hardware store."

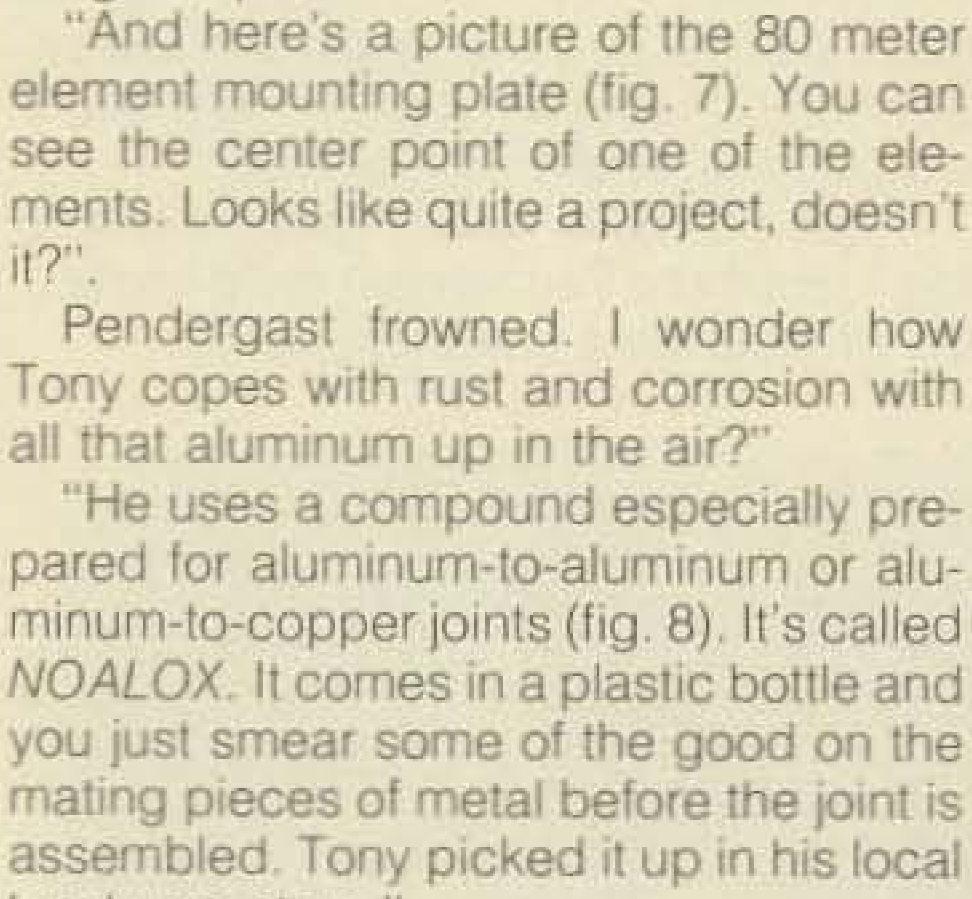

Fig. 6 — A tip of one 80 meter element at K3WX. A tapered winding is placed on a fiberglass pole to achieve end-loading. Winding is of copper strap.

Fig. 7 — The center-point and support for an 80 meter element at K3WX. Note the heavy-duty construction.

"Sounds great", agreed my friend. "That stuff should be an asset in any ham's shack".

I reached for the letters on the desk. "Observe the comments from Dave, W7TO. He's been using a short vertical antenna on 160 meters with a very small ground screen. He says he doesn't have room for a full set of 160 meter radials (who does?) and his solution to the problem is a ground screen made of one-inch chicken wire mesh that is 18 feet on a side. His antenna is a 27 foot vertical, top-loaded by a 50 foot wire. Dave says that the ground screen appears to work as well as a previous installation that used 1300 feet of radial wire, laid out like the spokes of a wheel in 70-foot lengths. With about 100 watts, he's managed WAS plus several overseas contacts. He's very happy with the ground screen".

"Speaking of the 160 meters, do you remember the '160 meter beam' antenna of G3XAP that I discussed in the May column? No? Well, it was a top-loaded vertical with the loading wire sloping down towards the ground. Directivity was in the direction of the sloper. Well, the concept was tried independently at VE7BS and he described his antenna in a recent issue of *Radio Communication*, the fine magazine of the Radio Society of Great Britain. Bob started out with an end-fed inverted-V (fig. 9) and then found out that results on long paths of 1,000 to 6,000 miles were improved by dropping the far end vertically, as shown in illustration (b). The latest experimental antenna (c) is a sloping, center-fed dipole with both ends vertical, based on the theory that the current flowing in the same direction in the vertical sections should make the antenna work like a pair of phased verticals. The whole idea is to get a low angle radiator without having to resort to a bunch of pesky radial wires".

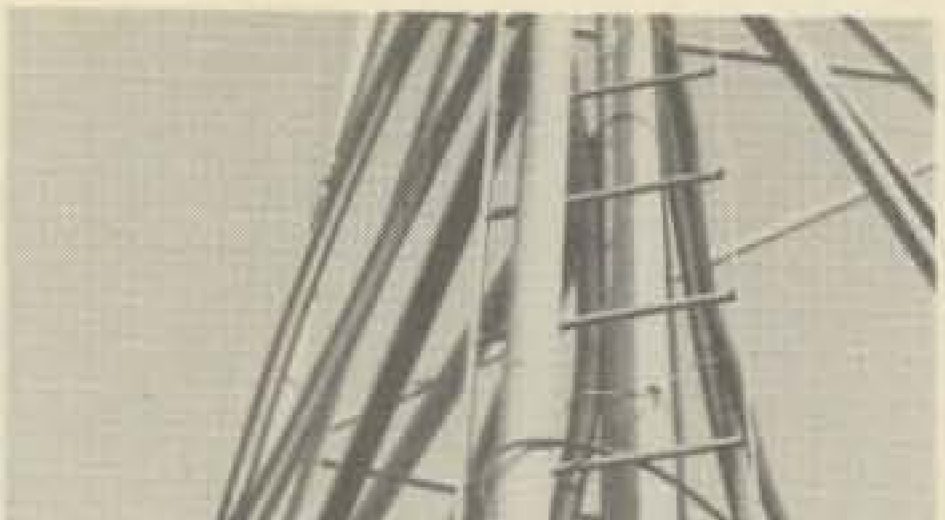

Fig. 8 — The 80 meter beam on its way up the tower, showing the center portion of a driven element. Note the heavy heliax cables coming down the legs of the mast!

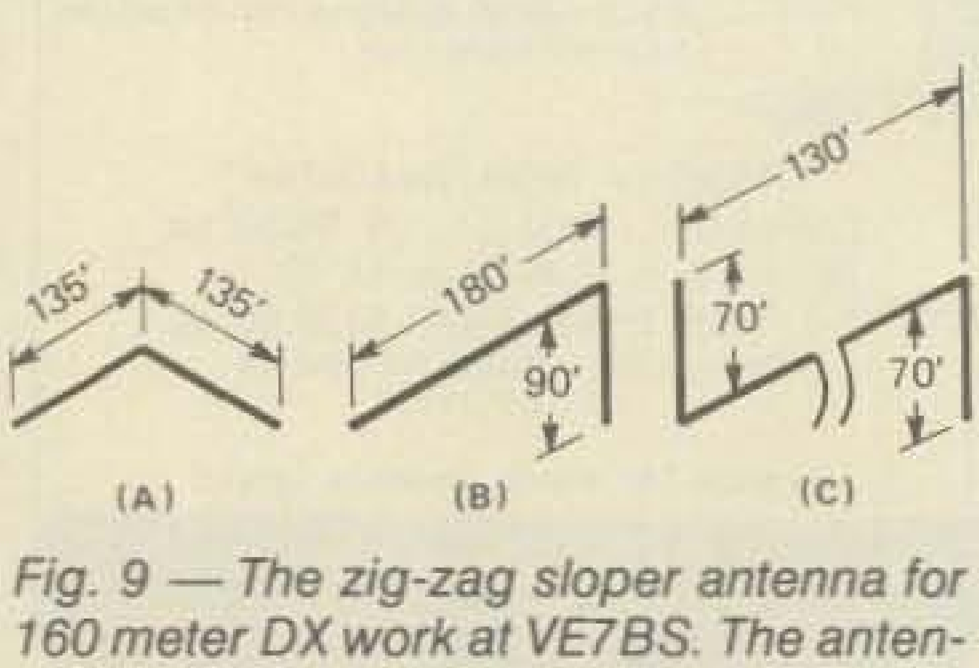

Fig. 9 — The zig-zag sloper antenna for 160 meter DX work at VE7BS. The antenna is designed to provide low-angle radiation without the necessity of laying out a lot of ground radial wires.

"Interesting", replied Pendergast, copying the drawing into his notebook. "And you can divide the dimensions by two and use the idea on 80 meters. That would make a nice, small antenna for DX work".

"You can get a lot of mileage out of simple wire antennas," I admitted. "Look at the Delta Loop that K5WR is using. Byron wrote it up in a recent issue of *Worldradio News*. All it is is a loop 71 feet in length, or 23'9" on a side. It is an equilateral triangle, fed at the apex with a 4-to-1 balun (fig. 10). The top is supported by a 25 foot TV push-up mast. The antenna works on 20, 15 and 10 meters. On 20 meters, the maximum s.w.r. is 1.65-to-1, on 15 meters it is 2.4-to-1 and on 10 meters it is nearly unity across most of the band. You can't ask for a more simple tri-band DX antenna than this. Byron worked 62 countries in the first month the loop was up".

Pendergast tossed a green-covered magazine across the table to me. "Here's another neat idea that was in a recent issue of *Radio Communication* (fig. 11). This is a very simple, wire Yagi beam for 40 meters. It can be supported from 30-foot high poles. Basically, it is an end-loaded beam using the horizontal supporting wires to provide capacitive end-

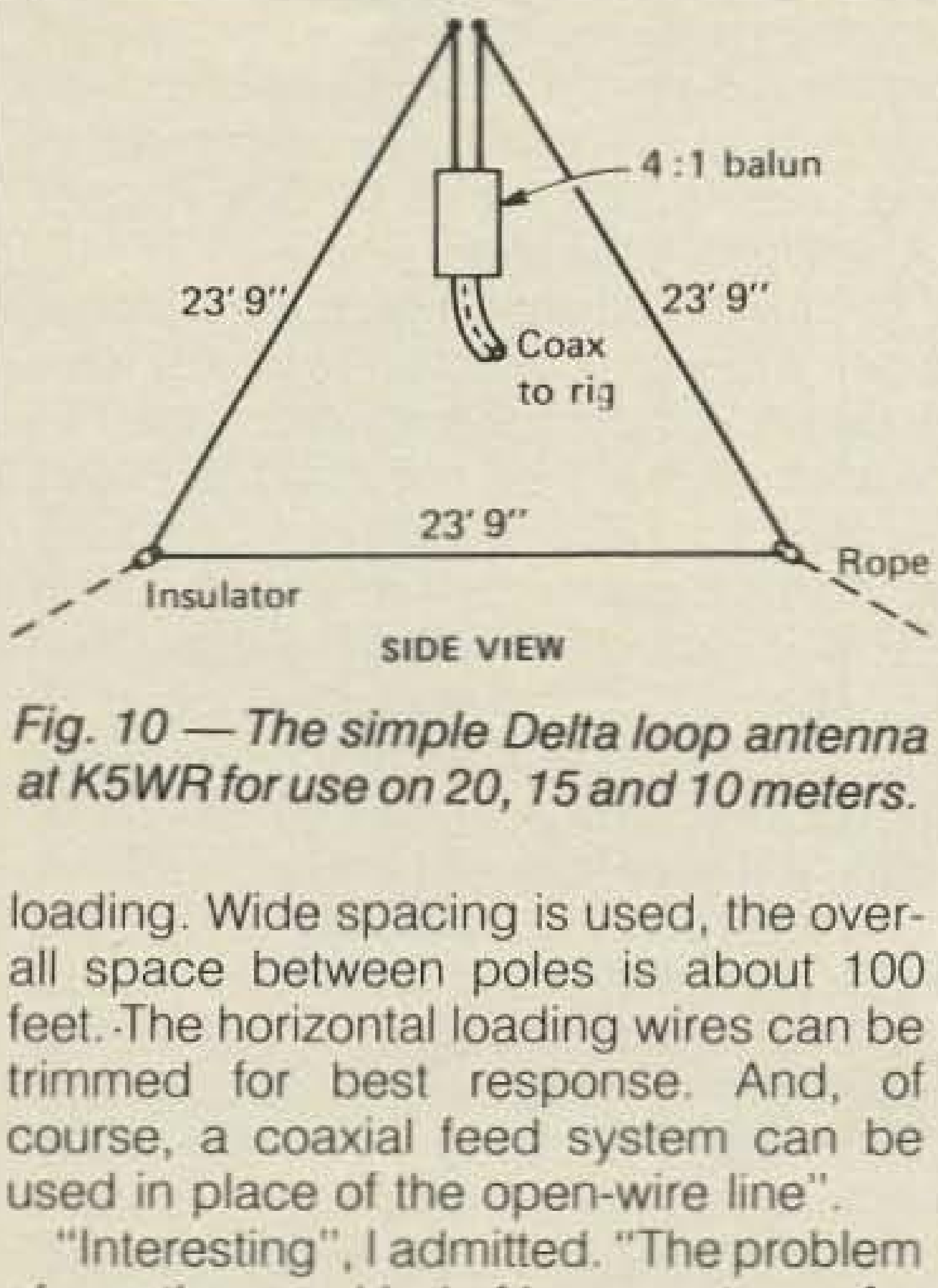

Fig. 10 — The simple Delta loop antenna at K5WR for use on 20, 15 and 10 meters.

loading. Wide spacing is used, the overall space between poles is about 100 feet. The horizontal loading wires can be trimmed for best response. And, of course, a coaxial feed system can be used in place of the open-wire line".

"Interesting", I admitted. "The problem of erecting any kind of beam antenna for either 40 or 80 meters is formidable, and I'm always happy to see a new design".

"Come to think of it, you can do a lot of tricks with a support rope slung between two tie-points", said my friend. "For example, Bruce, WB9SXX, has a rope slung between two tall trees. He wanted to work west to Asia and east to Europe for his two favored directions. So he put up three Delta Loops for 20 meters. He made the inner loop a reflector and then fed each outer loop with a coaxial line. By choosing which loop he fed, he had a two element beam aimed either east or west. The unused loop doesn't seem to influence the other two active loops. Bruce is only using an Atlas 210X transceiver but has had a lot of luck on 20 meters with this simple, cheap beam antenna!"

"Simple—and nice", I remarked. "And if any readers of this column have their pet antenna system, I'd be pleased to hear about it. Photographs are always welcome (black and white preferred) but even a simple pencil sketch will do. The last, new, interesting amateur antenna hasn't been built yet!"

"By the way", remarked my friend as he picked his earphones up from the floor, "How is your new antenna book doing?"

I gave Pendergast a dazzling smile. "I thought you'd never ask", I replied. "It is now in print. The title is *The Radio Amateur Antenna Handbook*. It is a fat 190 pages of good antenna dope for beginner and Old Timer alike. Do you want to know what Roy Neal, K6DUE, the famous Radio and TV News Correspondent has to say about it? Listen: 'I've enjoyed building and experimenting with antennas for many years. That's why I like this new book. It's full of ideas for every ham and . . . let's face it . . . in these days of high prices, antennas are the least expensive way of having a strong signal".

"Amen to that", said Pendergast.

Note: Bill Orr's new Handbook is published by Radio Publications, Inc., Box 149, Wilton, CT. Price: $6.95 plus 50¢ for postage and handling.

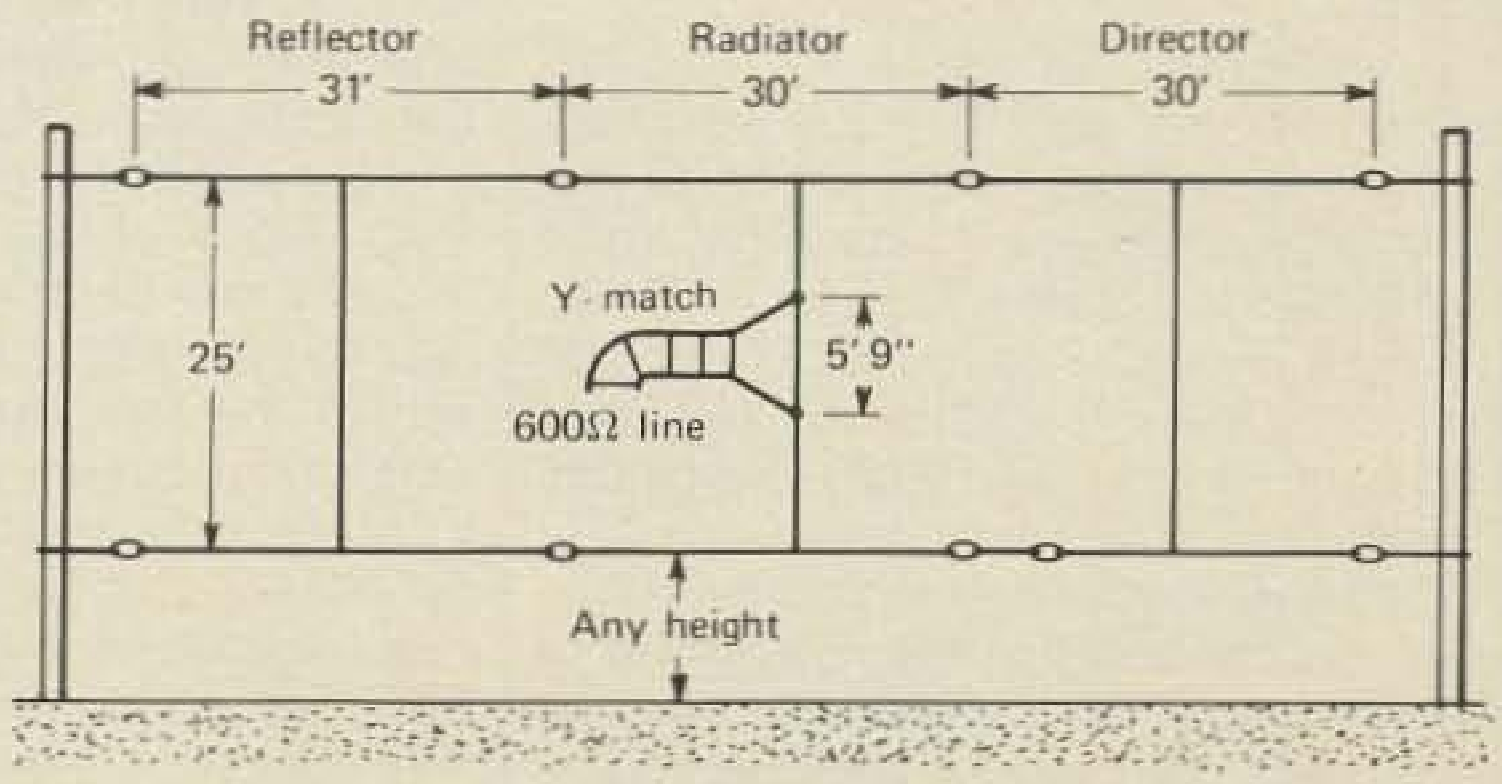

Fig. 11—A low-angle beam antenna for 40 meters using end loading. Antenna may be fed with 4-to1 balun and coaxial line. Directivity is to the right

No -69-70

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Antennas

Design, construction, fact, and even some fiction

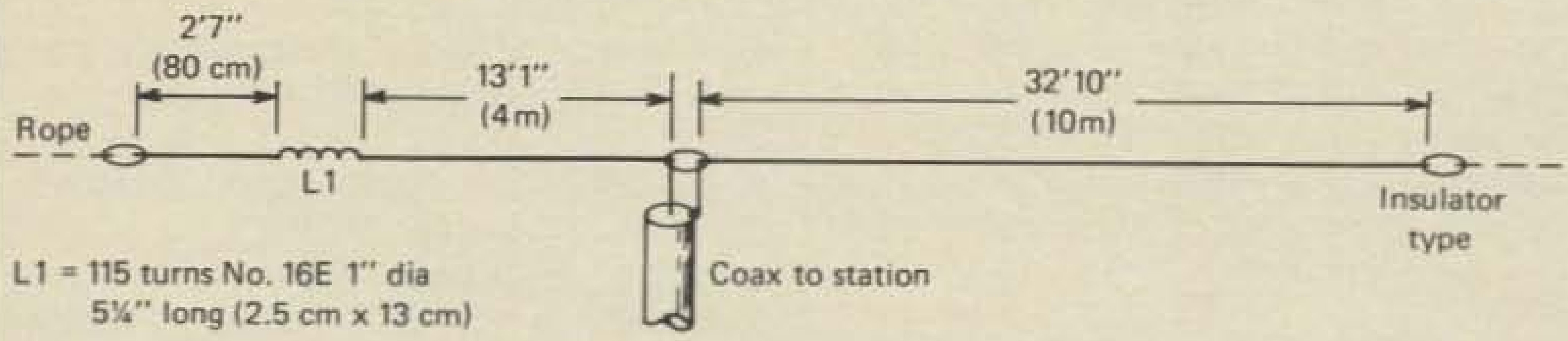

Fig. 1 — Short antenna tip beyond loading coil may be adjusted to move antenna resonance on 15 meter band. Antenna provides superior operation on both 15 and 40 meters. (Metric dimensions in parenthesis)

"Excuse me. I didn't know you had company". I closed the door to Pendergast's shack, but not too quickly to hear him call, "No, no! Come on in! I have a friend here I want you to meet". I entered the room. Sitting beside Pendergast at the operating table was a young fellow that I did not know. He had dark hair, a small beard and a quick and humorous look about his eyes. Pendergast rose and said, "I'd like you to meet a new radio amateur. Bill, this is Doctor Livingston I Presume. He's a dentist and just received his Novice license".

"Congratulations Doctor", I said shaking his hand. Doctor Presume grasped my hand and remarked, "You have been in Afghanistan, I see".

"A good point, Doctor", I replied. "And congratulations on your Novice ticket. Are you on the air yet?"

"Call me *Doctor Liv*", said my new friend. "No, I'm not on the air yet, but I soon will be. I was just chatting with Pendergast and I hope to swindle him into helping me put up an antenna".

48 Campbell Lane, Menlo Park, CA 94025.

Pendergast blushed with pride. "I'm always ready to help the humble beginner", he remarked.

"Pendergast, I love your humility", I said. "What do you have in mind for the good Doctor Liv?"

"Well, 15 meters is jumping these days. And 40 meters is always good for a local rag-chew. So I think that he should put up an antenna that would work on both bands".

"Agreed", I replied. "What do you have in mind?"

Pendergast thought a bit. "Well, how about a 40 meter dipole?

"That's resonant at the third harmonic, which is 15 meters. If Doctor Liv put up a 40 meter dipole, he could work both bands".

I turned to the good Doctor. "What kind of a rig do you have?"

"I just bought a *Kamikaze-200*. It's the new all-solid-state rig". He replied.

"Very nice"; I replied. "However, there's one problem. Most of the new solid state jobs don't like to work into any antenna system that has a high value of s.w.r. In fact, they protect themselves against high s.w.r. by a power reduction circuit. Thus: the higher the s.w.r. on the antenna, the less power output from the transmitter".

Dr. Liv frowned. "What's that got to do with using a dipole on its third harmonic?" he asked.

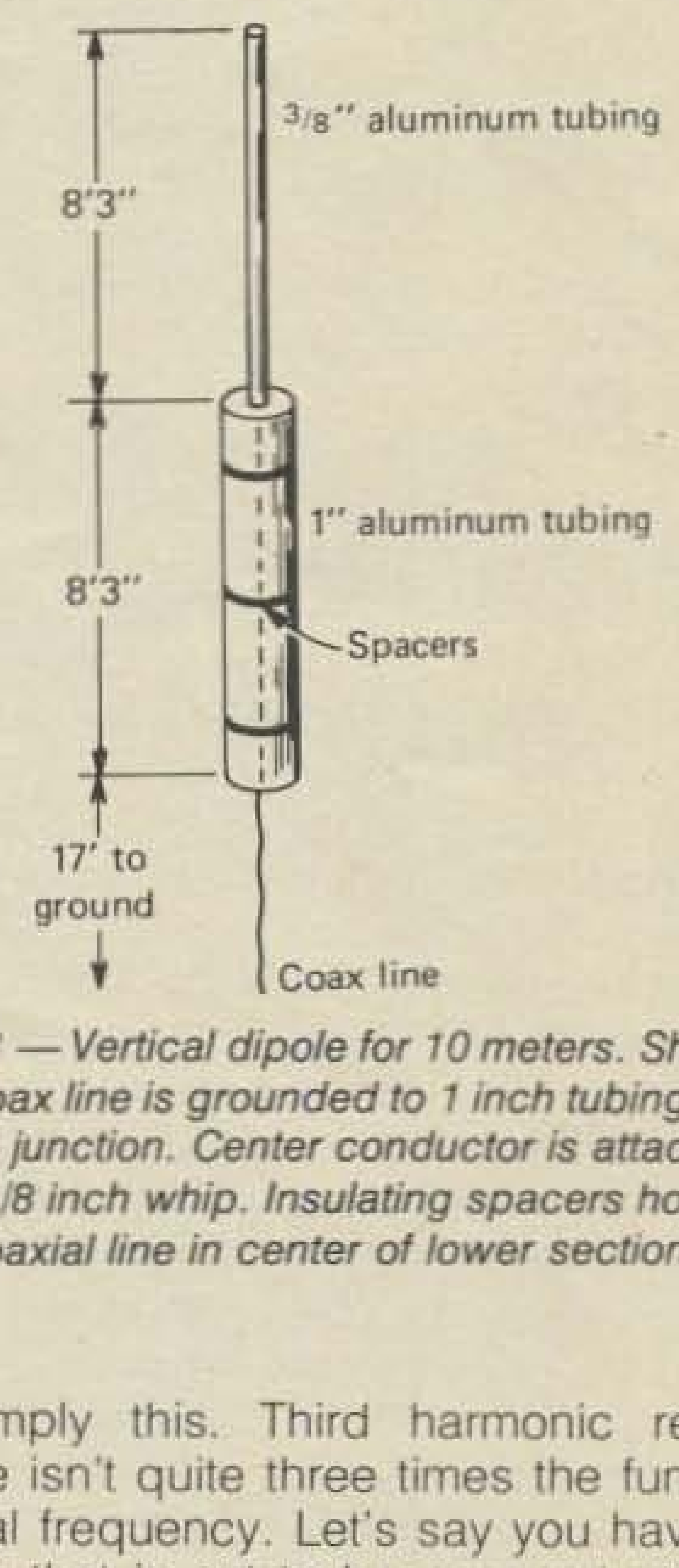

Fig. 3 — Vertical dipole for 10 meters. Shield of coax line is grounded to 1 inch tubing at center junction. Center conductor is attached to 3/8 inch whip. Insulating spacers hold coaxial line in center of lower section.

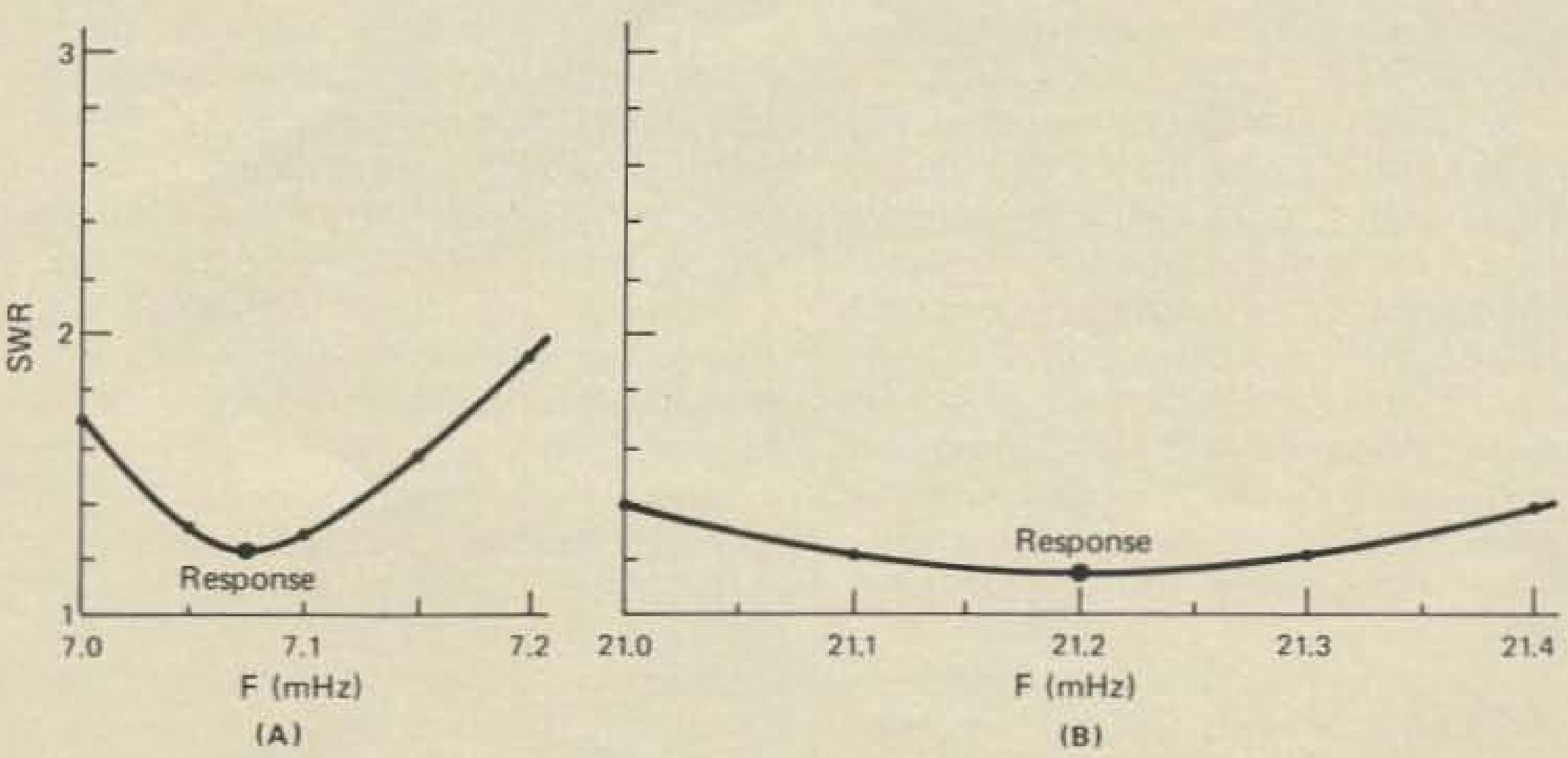

Fig. 2 — (A) Plot of s.w.r. on 40 meters. (B) Plot of s.w.r. on 15 meters.

"Simply this. Third harmonic resonance isn't quite three times the fundamental frequency. Let's say you have a dipole that is cut to be resonant at 7.1 MHz. You might think the third harmonic resonance would be three times 7.1 or 21.3 MHz. However, this is not the case. The third harmonic resonance actually turns out to be 21.8 MHz. This is far enough in frequency from the Novice band at 21 MHz. to cause s.w.r. problems with some types of solid-state equipment. And even some rigs that have tubes in the final amplifier (supposedly immune to high values of s.w.r. on the antenna system) might develop loading problems under such a condition".

"But I hear a lot of Novices on 15 meters that are using a 40 meter dipole", protested Pendergast.

"That may be so", I replied. "But there's a better way of doing the job that will provide operation on both 15 and 40 meters with very low s.w.r. on the transmission line"

With a flourish Dr. Liv produced a large, lined notebook.

"I'm taking your advice", he said with a smile. "Here's the start of my antenna notebook of good ideas".

"Well, this idea came from JA3CZV who wrote it up in the March, 1977 issue of *CQ-Ham Radio*, the Japanese amateur publication. Look at fig. 1. This is a 40 meter dipole with one branch shortened and tuned to resonance with a loading coil. The coil resonates the short side of the dipole to 40 meters but it upsets the current distribution on 15 meters to permit antenna resonance to occur at 21.2 MHz. instead of at 21.8 MHz. On 40 meters the s.w.r. readings for this antenna are below 1.6-to-1 across the c.w. band, rising to about 2-to-1 at 7.2 MHz. On 21 MHz., the s.w.r. is quite flat, running less than 1.4-to-1 across the whole band".

"Very interesting", said Dr. Liv, as he copied the drawing in his notebook. "Is there any adjustment to be made to the antenna?"

"If you want to move the resonance about at 40 meters, you trim or lengthen the short tip section after the coil", I replied. "Otherwise, leave it as it is".

"How do I plot a s.w.r. curve for this, or any other antenna?" asked the Doctor as he wrote busily in his notebook.

"All you need is an s.w.r. meter", I replied. "The little imported jobs that sell for under twenty dollars are just fine".

"I can see that you haven't been following the recent exchange rate between the dollar and the yen", observed Pendergast with a laugh.

I ignored the thrust. "The important thing to remember is that no adjustments to the transmitter, or changes in the length of the feedline, will affect the s.w.r. reading. The *only* thing that will affect the s.w.r. reading are changes made to the antenna. If you find that transmitter tuning, or changes to the transmission line affect the s.w.r. reading, then it is possible that something is wrong with the s.w.r meter or else you are measuring something else in addition to antenna parameters".

"I've heard from other Novices that you can change s.w.r reading by changing the length of the coaxial transmission line", observed Dr. Liv.

"You can change your *transmitter loading* by changing line length", I replied. "In fact, some fellows do just that. They cut short extension pieces of transmission line of various lengths and splice them to the main transmission line, thus changing the overall length of line between the transmitter and the antenna. And sometimes they find that a certain length of line loads the transmitter better than other lengths. This is very true, and it is a good technique to keep in the back of your mind when you run into loading problems. It is a quick and dirty means to load a transmitter that is working into a line having a high value of s.w.r. on it. But this sneaky trick doesn't change the *value* of the s.w.r. on the line, it merely changes the conditions of loading for the transmitter. If you are lucky, and hit the right line length, the transmitter may load up, regardless of the s.w.r. value. Now, that's not to be taken as a blanket statement! I'm only talking about *reasonable* values of s.w.r., say, less than 2-to-1. If you have a really high value of s.w.r. on the line, all bets are off and my statement is non-operative".

"That stunt doesn't always work", said Pendergast. It *usually* works with tube-type equipment that has both tuning and loading controls for the amplifier stage. By juggling line length, it is possible to get most pi-network tuned stages to load into a line having a reasonably high value of s.w.r. on it. And it is helpful with solid-state output stages, too. But many times it won't work on a solid-state rig, or if it does permit proper loading, the s.w.r. is still too high to prevent the transmitter from developing full output. And you can spend a lot of time looking for the "lucky" line length that may not exist!"

"Well, what can you do about it?", asked Dr. Liv. He reached in his pocket and took out the instruction booklet for his new *Kamikaze-200*. He thumbed rapidly through it and said. "Yes, here it is. It states that with an s.w.r. of 1.5-to-1 the output is 70 percent of normal and with an s.w.r. of 2.0-to-1 the output is 45 percent of normal. That's not so good. And as I understand it, every antenna is resonant at only one point in the band and the s.w.r. is lowest at that point. This means the s.w.r. is higher at other points in the band. Right?"

"That's right", I replied. "And this brings us back to the question you asked about running an s.w.r. curve for a given antenna. Let's take the antenna shown in fig. 1.

"You run an s.w.r. curve by measuring the s.w.r. at various points across the band. The s.w.r. meter instruction manual tells you how to make an s.w.r. measurement so I won't insult your intelligence by repeating that. It is common practice to make a measurement of s.w.r. every 50 kHz, starting at one end of the band and going to the other. On 10 meters, which is a rather wide band, the measurements may be made every 100 kHz. to save time.

"Write down the measuring frequency and also the s.w.r. reading. Then when you have gone across the whole band, you make up a graph. The s.w.r. measurements fall along the Y-axis and the frequency falls along the X-axis. Look at fig. 2. This is a plot of the s.w.r. measurements made for this Japanese antenna across the 40 meter band. Measurements were taken at 7.0, 7.05, 7.1, 7.15 and 7.2 MHz. Note that the curve is smooth and symmetrical. And note that the lowest value of s.w.r. falls between two of the measuring points".

Pendergast peered at the curve. "It looks to me as if the frequency of lowest s.w.r. is about 7.075 MHz.", he announced.

"That's right", I replied. "And if you went back and made another measurement at 7.075 MHz., that would verify this fact".

"I produced a second curve. "Here's the s.w.r. measurement of the same antenna on the 15 meter band. Points were plotted every 100 kHz. Note how broad the s.w.r. curve is. This is normal for an antenna working on the third harmonic".

"Have you ever though about using a vertical antenna?", asked Pendergast. "You can put up a triband vertical, or perhaps two separate ground planes. I like vertical antennas very much."

I reached into my desk drawer and brought out a bulky manuscript.

"This is a very interesting dissertation on vertical antennas", I said. "It is a military-sponsored investigation of the properties of vertical antennas for fixed-station use. Most of the information in the report is well known, but it brings out one important fact that has been overlooked these past few years, namely, that a vertical half-wave dipole can out-perform a ground plane antenna. The report summarized this fact by stating that an elevated dipole will improve low angle radiation by 3 dB to 5 dB over a ground plane antenna of equivalent height, and use of a vertical dipole is an attractive alternative to placing an extensive ground screen or radial system beneath a quarter-wave monopole".

"That sounds interesting", said Doctor Liv. "Do you have a practical example?"

"Look at the antenna in fig. 3", I replied. "This simple antenna provides more than 3 dB gain at low radiation angles than a ground plane with 40 radials mounted an equivalent height—seventeen feet—above ground. Now this is a simple antenna for 10 meters. And the dimensions can be scaled up for other bands, too"

"How do you feed this antenna?", asked Doctor Liv as he drew a picture of the vertical dipole in his notebook with a delicate touch.

"Well, if I was doing it, I would bring the coaxial line down inside the lower section of the dipole. It is easy to make spacers out of wood, or some insulating material, to space the coax right down the center of the tubing. That will prevent the field of the antenna from screwing up the proper

function of the coaxial line".

"Simple enough", said Pendergast. "Is there any magic height that the vertical dipole should be mounted above ground for best results?"

"The report had many charts of angle of radiation versus height of the dipole above ground. For best results the bottom of the dipole had to be a minimum of 0.5 wavelength above ground. Slightly better results were achieved at a height of 0.75 wavelength".

Pendergast frowned and said, "this is contrary to all published information on vertical dipole antennas. According to conventional wisdom, the higher the dipole above the ground, the less will be the low angle radiation".

"That's true", I admitted. "And that's one reason the investigation was run. It revealed the fact that when a vertical dipole is placed above the actual ground, which has mediocre conductivity, the radiation patterns are quite different from the patterns of a similar antenna placed above a perfect ground. And most theoretical studies and tests are done assuming a perfect ground. As you know, most tests are run on a v.h.f. antenna range which has a large copper sheet for a ground. But that isn't the way it is in true life. The best natural ground is sea water. But the conductivity of sea water is only a fraction of that of a copper plate. And the conductivity of soil is only a fraction of that of sea water. So the measurements made on an antenna over an ideal ground don't bear much resemblance to real life, where the antenna is mounted over lossy earth".

Pendergast breathed deeply. "Then all those pretty little pictures in the handbooks that show angles of radiation at various heights above ground just aren't true for antennas mounted above lossy ground?"

"I won't go so far as to say that", I rejoined. "This study only compares the performances of a ground plane antenna against a vertical dipole antenna. The study conclusively showed that the dipole out-performed the ground plane when both were mounted at least 0.5 wavelength above average soil".

"Well, I'll be dipped", said Pendergast. "Seems to me that the vertical dipole antenna is a lot easier to get up in the air than a ground plane with all those messy radials".

"Could be", I replied. "I hope some amateurs will try this antenna out and let me know their experiences with it. After all, the real proof is in how well the antenna really works. If this report is factual, I think we are in for some interesting antenna experiences!"

Doctor Presume shook my hand as he prepared to leave.

"Thanks for the bull session", he said. "I'll let you know how I come out with my experiments.

a monthly feature by

WILLIAM I. ORR, W6SAI

Antennas

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It was very quiet outside as the falling snow masked the distant sounds of an occasional atuomobile crunching along the street. Inside the house, the three friends sat around the fire, nursing their drinks. The clock had just struck two in the morning.

Twenty meters had been excellent up to sunset and forty meters had been very good; there were plenty of Asian signals coming in very strong in spite of the annoying broadcast signals and jammers that infested the band. About midnight the activity dropped off and by one o'clock the station had been secured. The lure of the log fire and conversation, however, precluded anybody from leaving soon.

After the long pause, during which each was occupied with his own thoughts, one of the amateurs, Dr. Livingston I. Presume, spoke, "Well, 1979 is only a few days away. How do you think DX conditions will be during the coming year?"

Pendergast shifted comfortably in his chair. "From what I read and hear it seems as if things are going to be pretty good. The sunspot cycle is predicted to hit a maximum of about 115 or 120, probably during the end of 1979 or the beginning of 1980. And 10 meters had been excellent this fall. I'm looking forward to a great DX season this coming spring."

Doctor Livingston turned to me. "What do you think?", he asked as he sipped his drink. I reached behind me and picked up a piece of paper from the operating table.

"Look at this", I replied. "Here's an article I saved from the September, 1978 issue of *Sky and Telescope* magazine. It was in the "News Notes" section. It is entitled, "Forecasting the Next Sunspot Maximum" and reports on the forecast made by R.P. Kane, who is at the World Data Center-A for Solar-Terrestrial Physics, Boulder, Colorado. He bases his forecasts and predictions upon the fact that the amount of disturbance of the geomagnetic field is a good indicator of the properties of the following sunspot maximum.

"The earth's magnetic field is constantly undergoing slight changes which are described in terms of the index number, *K*, in three hour intervals.

"A short time ago, the French geophysicist Mayaud had the clever idea of combining K numbers obtained simultaneously by observers at opposite points on the earth's surface to derive a new index number called *aa*. The number *aa* has the advantage of cancelling out the diurnal and annual changes in *K*. And, when the yearly mean values of *aa* are taken, the correlation is very good with respect to the sunspot cycle over the past 100 years.

"Dr. Kane has run this correlation and he predicts that the maximum annual sunspot number will be about 206. Taking into account the spread in the correlation, he predicts there is a 66-percent chance that the actual value will range between 160 and 250. Further, he predicts the maximum will fall near the end of this year: 1979. He wrote of his summaries in *Nature* magazine".

"A sunspot maximum of about *two hundred and fifty!"*, exclaimed Pendergast excitedly, as he nearly upset his drink. "Think what that will mean! The last great sunspot cycle peak in 1958 only hit about two hundred. I remember that one! The MUF was above the six meter band. six meters sounded like twenty meters! I had a little four element Yagi and worked all continents on six meters except Asia. And plenty of the six meter DXers on the West Coast worked into Japan. Many of the DX signals were so loud that they completely blocked my receiver!"

Dr. Livingston turned to me. "That was before my time", he said. "Was it really like that?"

"It was", I replied. "I remember I had a war-surplus *Hammarlund SP-600JX* receiver on the bench for alignment. I had a clip-lead connected to it for an antenna so I could hear my signal generator. I started to line up the six meter range when I experienced interference that blocked out the signal generator. When the interfering signal signed, it was an amateur in Argen-

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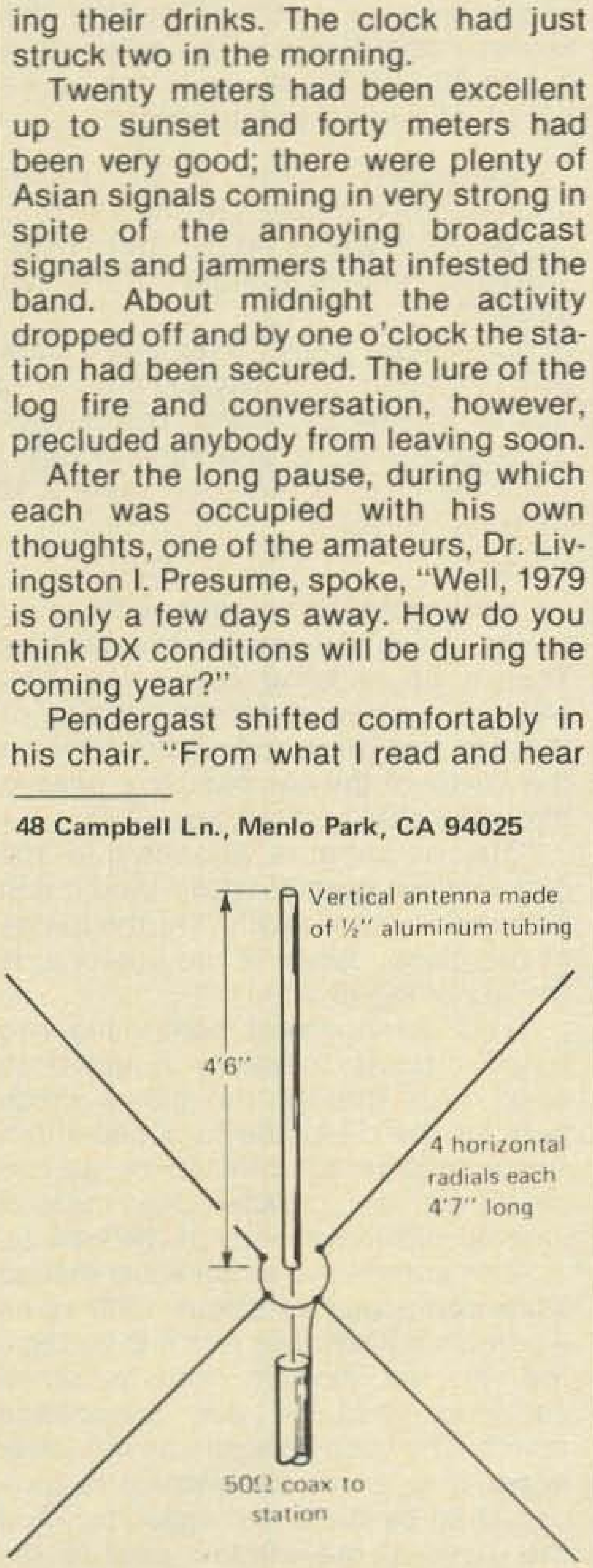

Fig. 1 - Six meter ground plane connect radial wires to braid of coax. Connect vertical antenna to center conductor of coax. Radials lie in horizontal plane. Radials may be made of insulated wire, or of light aluminum tubing or rod.

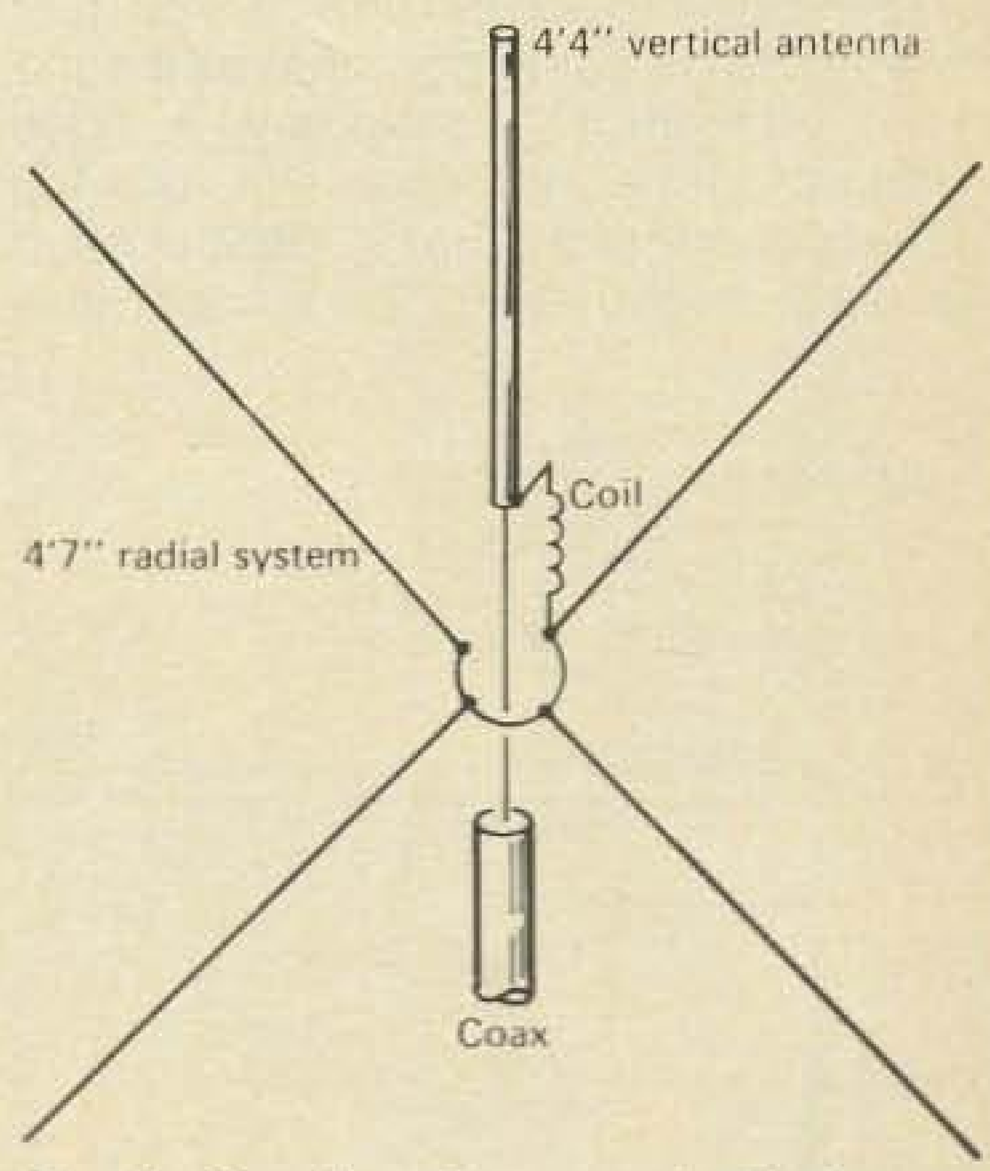

Fig. 2 - Small coil connected between base of vertical antenna and radial system provides simple matching device to achieve very low s.w.r. on coax transmission line. Start with six turns, one inch in diameter and two inches long. Monitor s.w.r. on line and reduce coil turns to achieve lowest s.w.r.

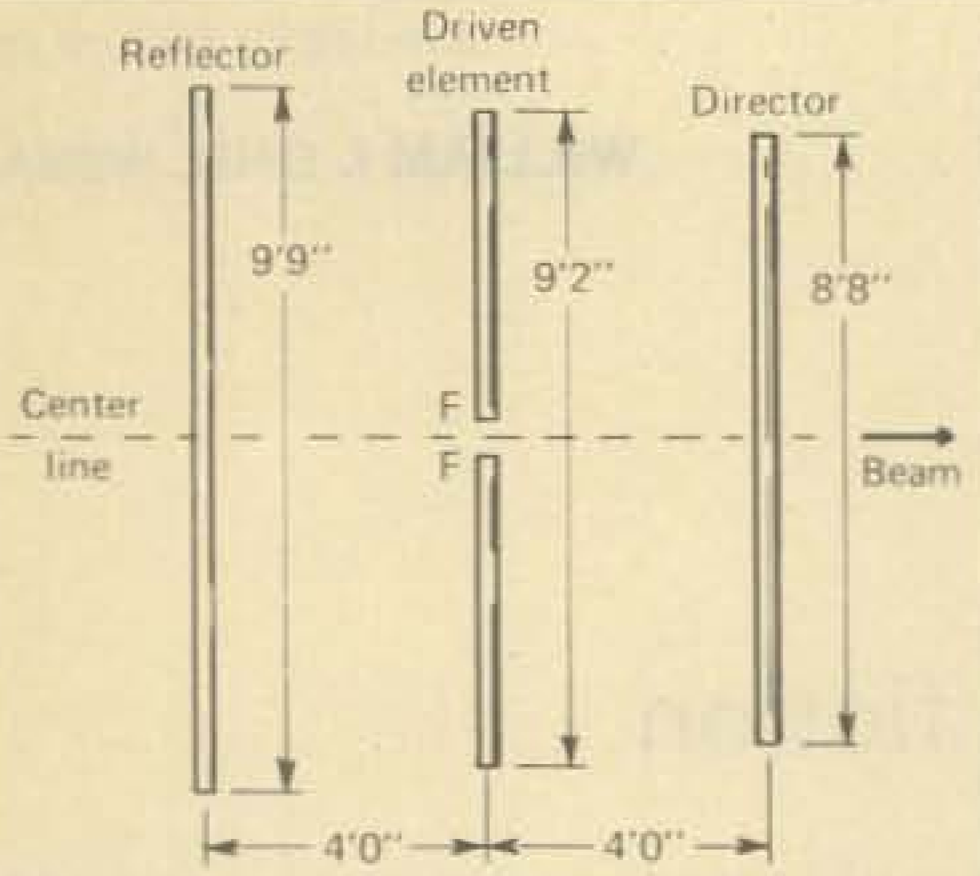

Fig. 3 – Top view of 6 meter beam as built from parts of CB Yagi antenna. Mechanical details not shown because of differences in purchased antennas. Some CB antennas are fed at F-F if driven element is split and insulated from boom. See various antenna handbooks for other feed systems. If CB antenna has a gamma match system, for example, dimentions may be reduced by 40% to allow adjustment to six meters. The match is tuned for lowest s.w.r. value on transmission line at 50.1 MHz.

tina! He was louder than my own signal generator.

"Last spring and fall the six meter band was full of double-hop, sporadic-E DX signals. Plenty of cross-continental DX, plus openings to Hawaii and the Central American area. And now, with the support of the rising sunspot cycle, six meters is going to be even more of a DX band".

"Well, how about an antenna. What do you recommend?", asked Doctor Livingston as he opened his notebook to a blank page.

Pendergast spoke up. "If you just want to have some good fun and don't take yourself too seriously, a good ground plane antenna will provide plenty of contacts (fig. 1). Best of all, it is quite unobtrusive. The easiest way to build one is to buy a cheap CB ground plane for 11 meters and cut it down to size. The vertical radiator should be only 4'6" high. And each radial is only 4'7" long.

"The feed-point of the ground plane is about 35 ohms. You can feed it directly with a 50 ohm line if you don't mind a slight s.w.r. on the line. It will be about 1.4-to-1 resonance, rising gradually off-resonance to about 2-to-1 at 52 MHz. Lowest s.w.r. will be close to 50.0 MHz. as this antenna is cut for the low end of the band".

"There are several ways you can lower the s.w.r., if you wish", I remarked. "You can reduce the length of the radiator to 4'4" and then place a small coil across the feedpoint, in parallel with the coaxial line. Watch the s.w.r. on the line and then adjust the number of turns in the coil for the lowest value of s.w.r. at your pet frequency. This is very easy to do".

"An easier scheme is merely to droop the radials downward", exclaimed Pendergast. "If the radials droop down at about a 45 degree angle, they tend to radiate a bit. This raises the feed point impedance of the antenna to close to 50 ohms. And you don't have to fiddle with a matching coil".

"Either idea is OK", I said. "But if you *really* want to have a good signal on six meters, I recommend a beam antenna. And the simplest beam to get working is a Yagi. Again, I recommend that you buy a CB Yagi antenna. They are very inexpensive. Mount the beam horizontally instead of vertically. Since the spacing is quite wide, the antenna dimensions will be relatively noncritical and the beam will provide you with good gain. Cut the director to 8'8", the driven element to 9'2" and the reflector to 9'9". That will give you good gain and good front-to-back ratio".

"How about a matching system?", asked Doctor Livingston as he drew a graceful picture of the beam antenna in his notebook.

"Well, I'd use the same technique that we discussed for the ground antenna. That is, reduce the overall length of the driven element about two inches (an inch shorter at each tip) and place a matching coil across the feedpoint. The 50 ohm coaxial line is connected directly across the feedpoint".

"No balun?", asked Doctor Livingston, arching his eyebrows.

"I'd use a compromise balun", I replied. "Just wrap the coaxial line into a coil. About three turns, eight to ten inches in diameter will do the job. It is not wise to make the coil too small in diameter or else the inner coax conductor might cold flow and short out to the outer braid. Wrap the coil with a bit of tape and suspend it parallel to the boom. This simple inductor will choke off any antenna current flowing on the outside of the coaxial line. Don't forget to drop the line down vertically beneath the beam. A lot of fellows get into trouble because their transmission line runs parallel to the antenna elements. This produces coupling between the antenna and the outside shield of the coaxial line and cancels out the isolating effect of the balun. Best to run the line down the mast to the ground level and then bring it across to the station.

"To improve the match, measure the s.w.r. at your favorite operating frequency and adjust the number of turns in the antenna matching coil for the lowest value of s.w.r. The antenna is cut to 50.1 MHz., so tests should be run at, or near, that frequency".

Pendergast looked at his watch and executed a jaw-splitting yawn.

"After two a.m.", he said. "Anything else of interest before I run along?"

"One more item", I replied. "Look at this diagram of a new and interesting mobile antenna by Avanti. It should be of great interest to amateurs. In fact, I hope the manufacturer will make a 10 meter version of it.

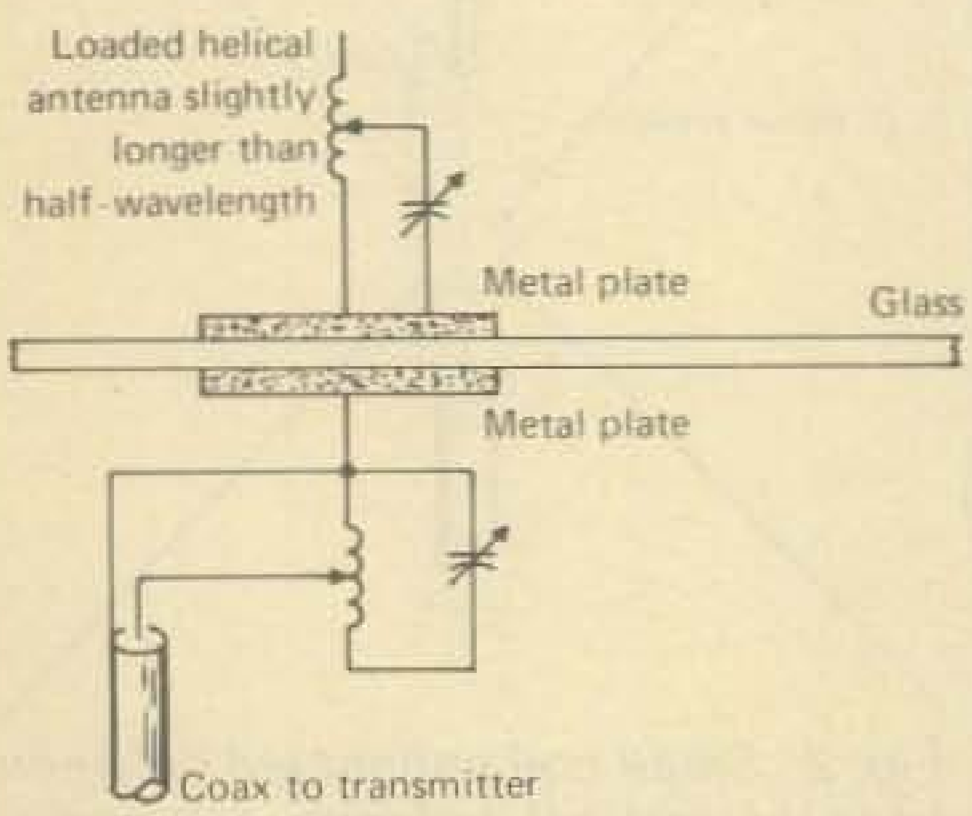

Fig. 4 – AVANTI mobile whip antenna makes use of window glass as dielectric of capacitor which couples two tuned circuits. No holes need be drilled in body of vehicle when this unique antenna is used.

"You'll note the antenna is mounted to the glass window of the vehicle. There's no physical connection between the antenna on the *outside* of the car and the transmission line on the *inside* of the car. No cable passes through the body of the car.

"The antenna is attached to the glass with a special epoxy. And it can be removed very easily. On the inside of the glass, opposite the antenna, is the matching unit.

"This arrangement comprises two tuned circuits, capacity coupled to each other through the glass, which acts as the dielectric in a capacitor. Resonance is established by adjustment of the parallel-tuned circuit located within the body of the vehicle.

"The antenna is a half-wave loaded whip composed of about 1000 turns wound in a fiberglass rod. It is voltage-fed at the bottom and a small capacitor adjusts the impedance match. The whip presents an inductive impedance at the base which is compensated by the small capacitor. And the glass of the window acts as the coupling capacitor".

"That's pretty classy", observed Doctor Livingston as he studied the sketch. I'd bet that the CB antenna could be jiggered up into the 10 meter band. And I like the idea of mounting the antenna to the window!

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Pendergast and Doctor Livingston I. Presume caught me at my desk looking over the morning mail. They dropped their jackets on the operating table and slowly started to thaw out. It was bitter cold outside. The windows were frosted over and when my two friends opened the door to the shack a scimitar of icy air slashed across the desk, whisking some of the mail to the floor.

I bent down to pick the letters up as Pendergast asked, "Any good DX QSL cards in the mail?"

"No, but there are plenty of bills", I replied.

"Always pay your Doctor's bill first", suggested Doctor Liv.

"I should adopt the Chinese method and only pay doctor's bills when I am healthy and stop paying them when I am ill", I responded.

Doctor Liv ignored the thrust and picked up a letter. "Hey", he said, "Here's a note from that well-known DXer Dick, W3GNQ. What's he got to say?"

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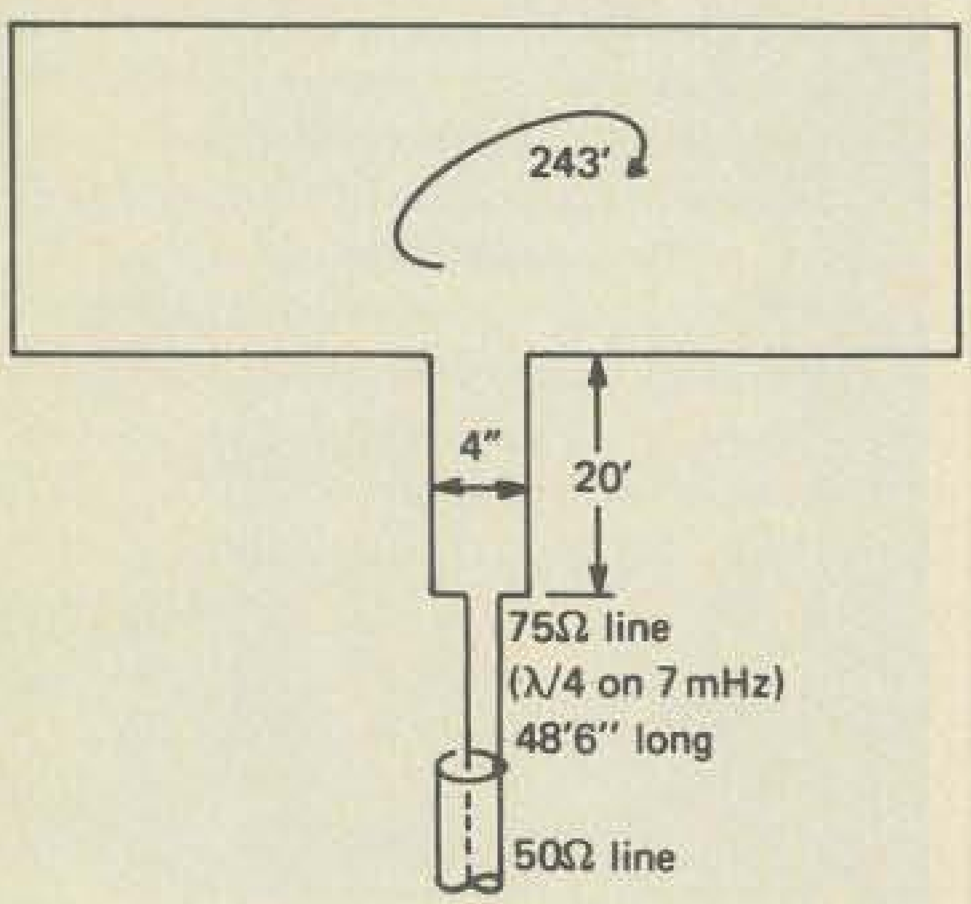


Fig. 1 - The W3GNQ loop antenna for 40 and 80 meters. The 75 ohm line is Amphenol 214-023 or equivalent. It is an electrical quarter-wave length for 40 meters (48'6"). Open wire line is home-made using 4" ceramic spreaders. Antenna wire size is number 12 solid copper.

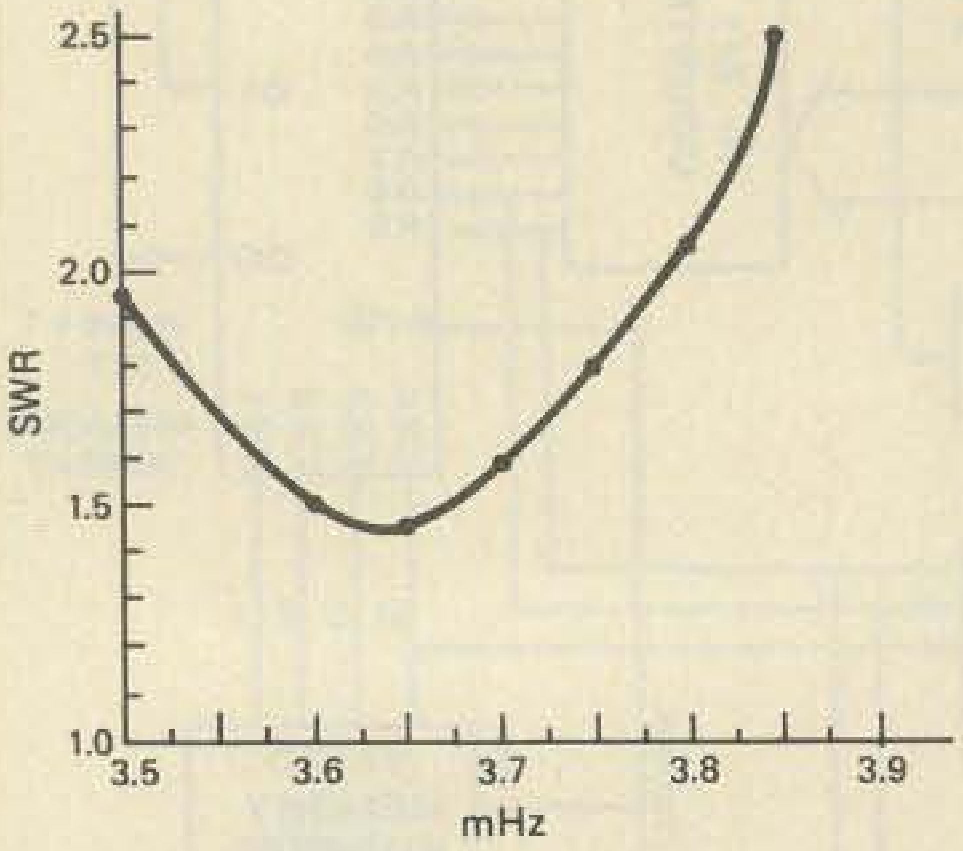


Fig. 2 - Plot of the W3GNQ Quad loop for 80 meter operation.

There were some drawings in the envelope. "This is a picture of W6TC Quad loop at W3GNQ", I replied. "Dick has modified it a bit to use it on *both* 80 and 40 meters (fig. 1). He made the loop a mite bit smaller than normal and fed it with a short, open wire transmission line. Then, the bottom of the line is fed with a 40 meter quarter-wave section of heavy-duty 75 ohm transmission line. Finally, a 50 ohm coaxial line runs to the station".

"It looks as if the loop is slightly shorter than a wavelength in circumference on 80 meters", said Pendergast, as he slowly removed his gloves and held his hands towards the fire.

"That's right", I replied. "This loop is 243' in circumference. But the open wire line is 20 feet long. That adds 40 more feet of wire, so the total amount of wire in the antenna system comes out to be 283 feet. That's slightly longer than a wavelength at 80 meters, but the overall length is annulled a bit because some of the wire is in the transmission line. In any event the system is resonant at about 3650 kHz. As you can see from Fig. 2, the bandwidth of this loop is very good on 80 meters.

"How about 40 meters? That's my favorite band", said Doctor Liv. He had made himself at home and was pouring himself a glass of good California white wine from a bottle in the refrigerator.

"The antenna works on 40 meters, just as well as it does on 80 meters", I replied. "The SWR plot for 40 meters is shown in fig. 3. The s.w.r. is very low across the whole band. The frequency of minimum s.w.r. is about 7.2 MHz. Note that on 40 meters, there's a quarter-wave matching section made of 75 ohm heavy-duty two-wire line between the antenna and the 50 ohm line. I would imagine that you could use a length of 75 ohm coaxial line, such as RG-11/U, if you can't find the two-wire line".

"Do you have to remove the quarter-wave section when you use the antenna on 80 meters?", asked Doctor Liv., as he sipped his drink.

"No", I replied. "That's the beauty of it. The 75 ohm line has practically no effect on 80 meters. You can jump back and forth between 80 and 40 meters, phone or c.w., without doing a thing to the antenna!

"The best form for the loop is square or triangular and polarization is horizontal. For a square loop, each side is 60'9" long. For a triangular loop, supported at the apex, each side is 81 feet long *or* you could make the loop rectangular in shape, say 50 feet high and 143 feet long. The actual shape of the loop is really not so important. You can call this a very forgiving antenna design".

"You can call me Ray. Or you can call me Jay....", began Pendergast. Doctor Liv. quickly put the

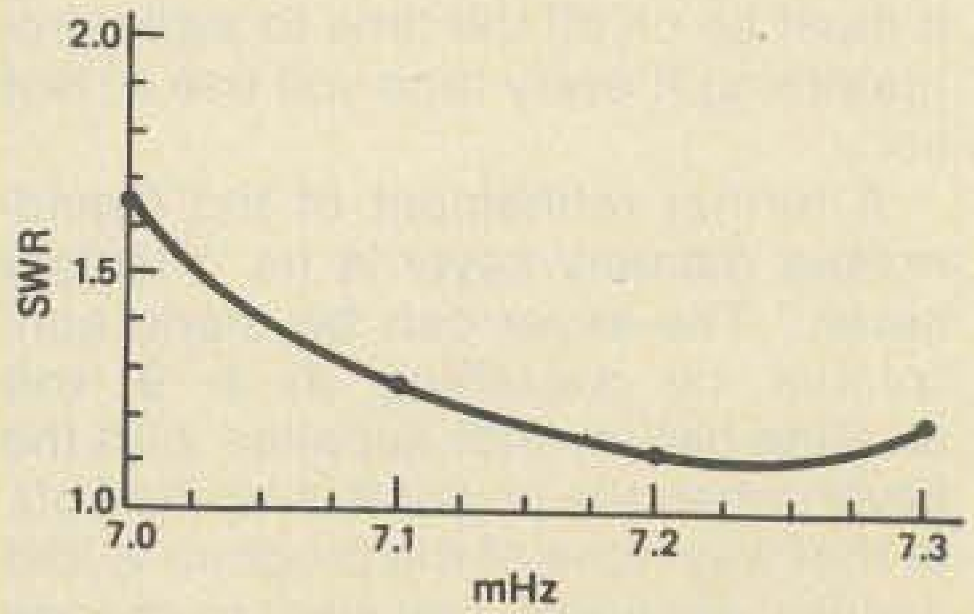


Fig. 3 - Plot of the W3GNQ Quad loop for 40 meter operation.

wastebasket over his head and snapped, "Shut up!". Pendergast tossed the basket into the corner of the room and said, "I was just trying to help".

"Dick says he's had a lot of luck with this simple loop and has worked a lot of DX with it this past season. I think it's a pretty good sky-wire for the operator who wants both 40 and 80 meter operation with one simple antenna".

"I really enjoy working with loop antennas", said Doctor Liv. "I'm putting one up like the version at K7WA. Jim has a small, loaded loop for 40 and 20 meter operation. It is 33 feet long on a side and has loading coils at the high voltage points. He designed the antenna after some investigations conducted by ZL1OI and G3FPQ. It looks like fig. 4.

"Jim adjusted the coils for lowest s.w.r. on 40 and 20 and tuned the antenna with a *Viking Match Box* and a s.w.r. meter for operation on either band. He's only running 75 watts but works plenty of DX on both bands. I think this is a pretty good two-band loop antenna".

"Agreed", I replied. "It has to be good to work DX with only 75 watts. A little experimentation is necessary with the coils as Jim didn't send any data. But all that has to be done is to adjust the number of coil turns for lowest s.w.r. on 40 meters. Twenty meters will probably take care of itself".

Pendergast broke his silence and pulled a letter from his pocket. He tossed it to me, saying, "I just received a note from Bob, WB5QGI. You probably remember him as WB4DPG. He sent in the information on the wire antenna that was given in the February, 1976 issue of this column in *CQ* magazine. Since then, he's moved to Texas. . . ."

"Poor devil", muttered Doctor Liv. under his breath.

Pendergast continued, "Bob has a 33 foot metal tower with a 2 meter ground plane atop it at one end of this house. He's got two sloper antennas attached to the tower, one for 80 meters and one for 40 meters (Fig. 5). And he likes them both".

Pendergast put on his glasses and started to read the letter.

"I haven't seen any simple-simple antenna that equals the sloper for overall performance (he writes). The sloper, if you remember, is a quarter-wave wire, fed at the top, and worked against a metal tower as a ground.

"The 80 meter wire is about 65 feet long. And, as I found out with my first sloper, it is necessary to vary the slack in the wire and swing the bottom end around. This really makes a difference in the s.w.r. measurement. I wonder how many fellows who have put up a sloper antenna in "guy-wire" fashion have found it less than satisfactory and considered it a waste of time—all due to not experimenting with it a little? Several amateurs around here, after hearing about my success with the sloper, have put one up and the degree of success seems to vary directly with the willingness to "play around" some with it.

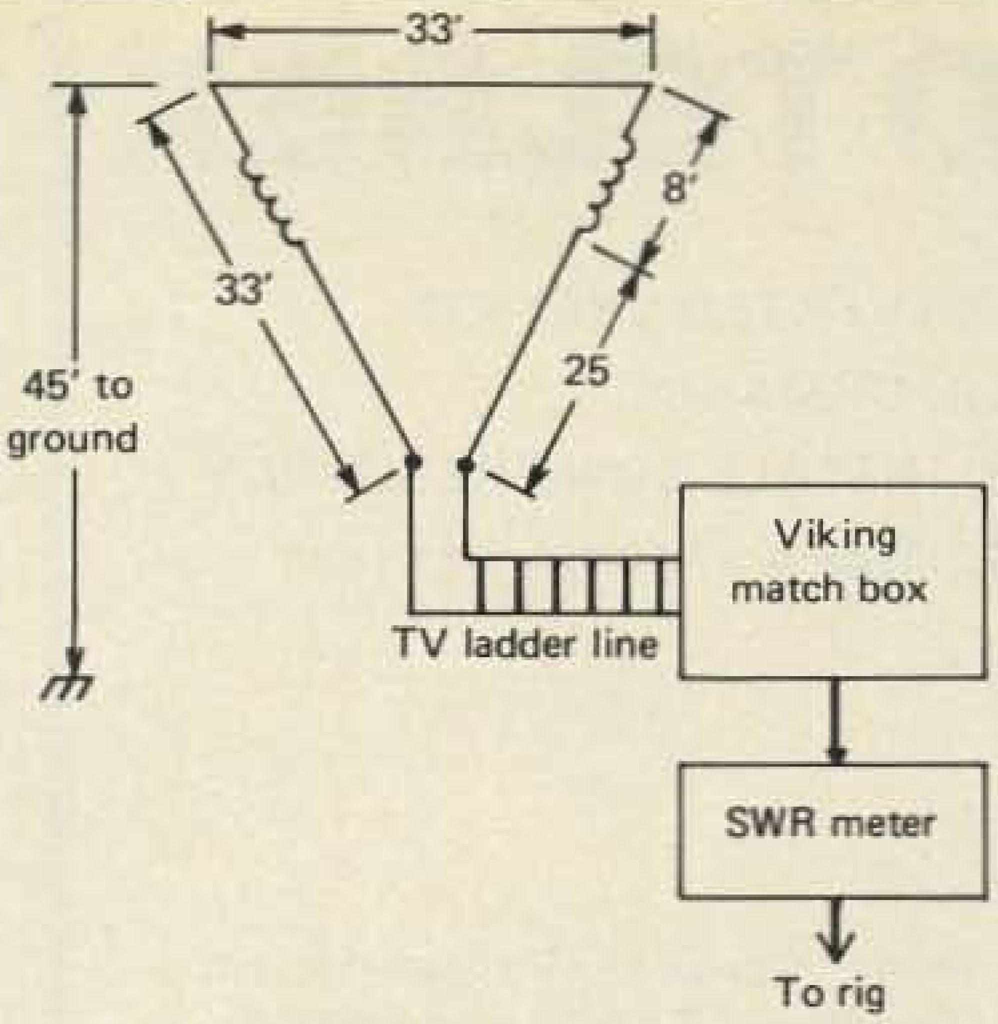


Fig. 4 - The compact 40-20 meter loop antenna at K7WA.

"After I got the 80 meter wire working, I put up a second wire, about 33'4" long, for 40 meters. It is fed in parallel with 80 meter wire and hangs down from the tower, but at an angle of about 45 degrees around from the original wire, looking down from the top. As with the 80 meter wire, it was necessary to vary the amount of slack in the wire and to swing it around a bit until the lowest value of s.w.r. was obtained.

"The SWR on 80 meters is better than 3-to-1 at the band edges and better than 1.5-to-1 from 3.7 MHz. to 3.95 MHz. This is important as I use a HW-104 and this gives me a lot of flexibility, taking into account the broadband capability of the HW-104.

"The s.w.r. on 40 meters is less than 1.4-to-1 at the low end of the band and less than 1.3-to-1 at the high end. I can also use the antenna on 15 meters and on 10 meters, although the s.w.r. on 10 meters is higher than I like. I've also used it on 20 meters, but the s.w.r. runs about 10-to-1 on that band."

Doctor Liv. cleared his throat and said, "I keep hearing that 3-to-1 is the maximum s.w.r. value you can have with modern transmitters. Or maybe even less. Some of the solid state transmitters have a fail-safe circuit that gradually turns off the power amplifier when the s.w.r. value is high. So you put out less and less as the s.w.r. increases. The older tube-type amplifiers don't have that problem. They can work into quite high values of s.w.r., until the limitations of the pi-network output circuit are exceeded. But a lot of amateurs don't realize that if you place an antenna tuner in the line between the line and the transmitter (keeping an s.w.r. meter in the transmitter portion of the line) it is possible to adjust the tuner to take out the greater portion of the high s.w.r. Even when the s.w.r. is very high the antenna can still be usable—even up to s.w.r. values of 10-to-1, *provided* the antenna tuner can match the high s.w.r. to the transmitter. I use a *Drake MN-4* matcher. It doesn't make the antenna any better, or lower the s.w.r. on the line to the antenna, but it makes the transmitter "see" a better load, allowing me to crank up the exciter without exceeding any limits. I wouldn't recommend this scheme with a high power rig, 'cause something may blow up due to high voltages where s.w.r. values are concerned, but at the 250 watt level, things are pretty

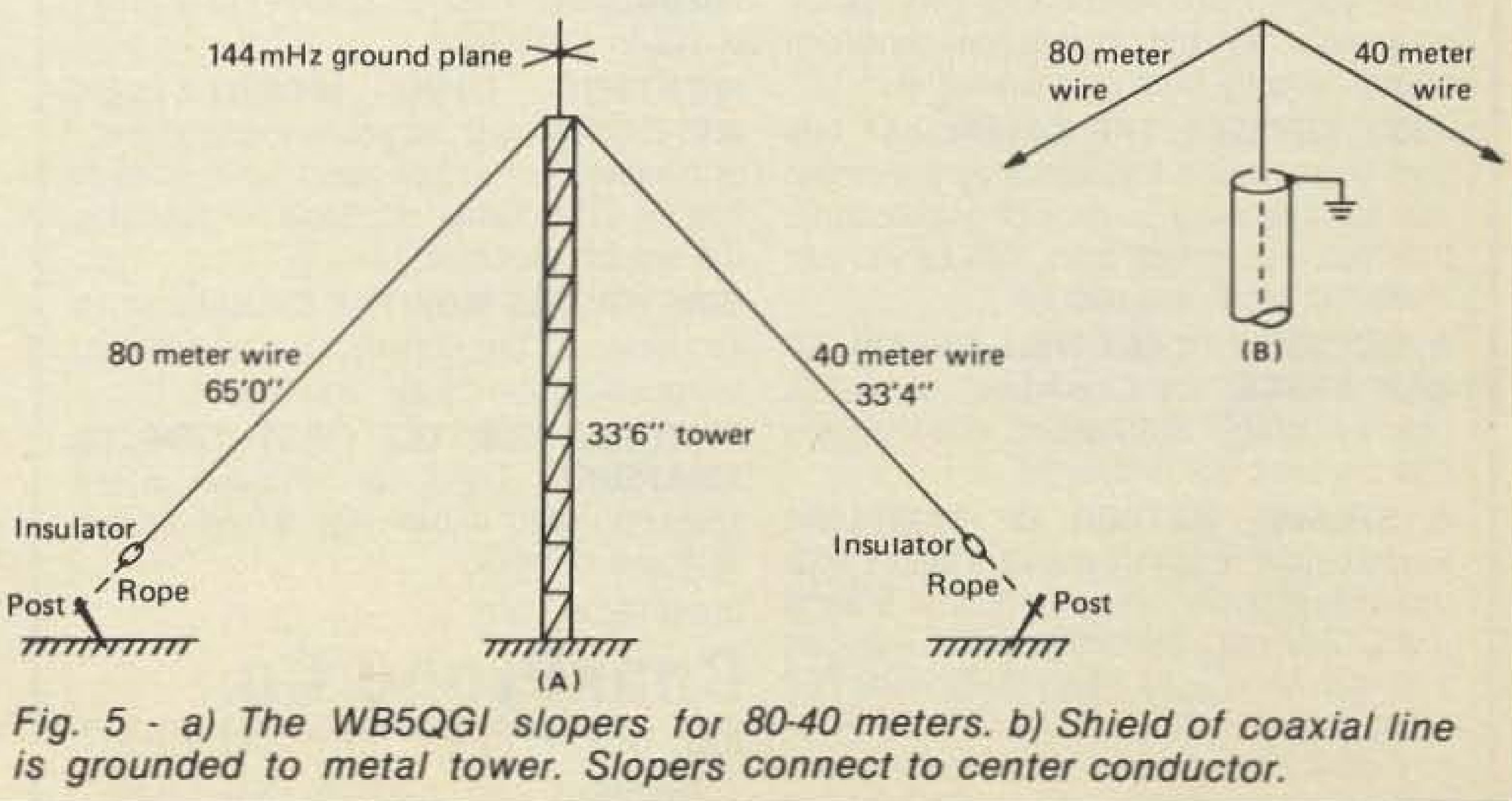


Fig. 5 - a) The WB5QGI slopers for 80-40 meters. b) Shield of coaxial line is grounded to metal tower. Slopers connect to center conductor.

safe. In any event, my tuner permits me to work into outrageously high values of s.w.r. on the antenna system".

"Right, as usual", I replied. "A low s.w.r. on the line is *nice* to have, but not essential. I have a 20-15-10 meter tri-bander beam and the s.w.r. at the edge of the 20 meter band is over 3-to-1. Some of my friends with a similar beam are worried sick about this and they fiddle around with the antenna to lower the s.w.r. Nonsense! That value of s.w.r. isn't significant *provided* the transmitter can accept that value. If the transmitter won't load into a high value of s.w.r., a simple antenna tuner or so-called "match box" between the transmitter and the coaxial line to the antenna will clean things up enough to permit proper transmitter loading".

"High s.w.r. *is* important in the v.h.f. region if you have a lot of line loss, because high s.w.r. boosts line loss. But this is unimportant in the h-f region. And if you are running a lot of power"—he looked at Pendergast who pretended to be intently watching an ant crawl across a stack of QSL cards—" you could flash something over. But with power levels below 250 watts, an antenna tuner permits you to operate your antenna off-frequency with good results. I've even used a 20 meter beam on 15 meters by the addition of an antenna tuner. It didn't set the world on fire, but *at least* I was on 15, and I did work the Clipperton Island DXpedition on 15 meters just that way!".

"You can't keep a good man down", Pendergast said, rejoining the conversation.

Doctor Liv. arose and made motions preparatory to leaving. he hesitated, and said, "How is your new antenna book doing?"

"Thanks for asking", I smiled. "Very good, And a lot of data about slopers and other interesting antennas are shown in the book. I'd give you a copy, but I would rather you bought one for yourself. After all, I'm not a rich dentist".

"Envy is a terrible thing", said Doctor Liv. "But you are rich in spirit, and that's really what counts".

Note: The handbook Doctor Liv referred to is W6SAI's newest work, entitled "The Radio Amateur Antenna Handbook". This 188 page handbook covers interesting antennas from A to Z. Available from Radio Publications, Inc., Box 149, Wilton CT 06897. Price: $6.95 plus 50¢ shipping and handling.

a monthly feature by

WILLIAM I. ORR, W6SAI

Antennas

Design, construction, fact, and even some fiction

Doctor Livingston I. Presume poked his head in the door and asked, "May I come in?"

"Certainly", I replied. "But I have a better idea. It is such a beautiful spring day, let's sit outside and absorb some sunshine".

I opened the door to the shack and sat down beside Doctor Liv on a wooden bench. The warm spring sunshine felt good and it seemed as if the long, cold winter was at last over.

"Where's Pendergast? I haven't seen him for some days", I asked.

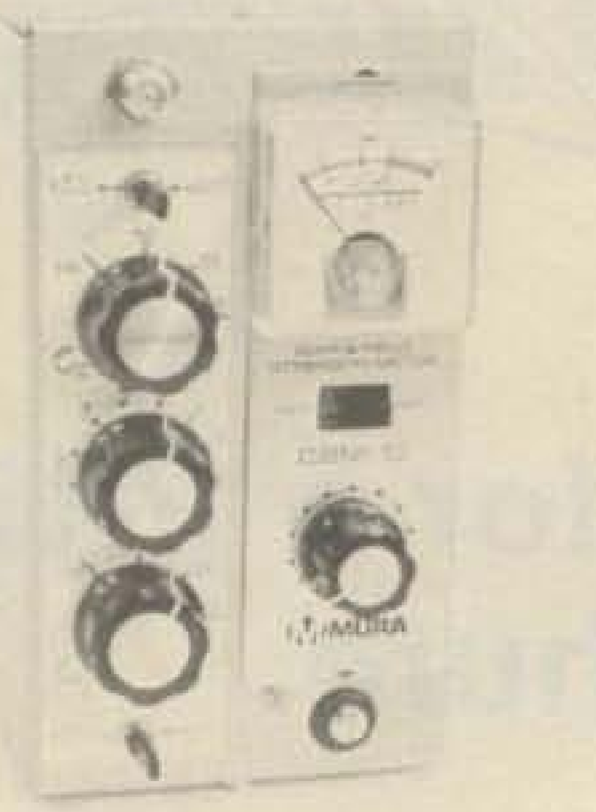


Fig. 1—The K6VQ Mini-antenna tuner and s.w.r. meter. Using an inexpensive CB-type s.w.r. meter and a homemade tuner, this compact device is used with an Atlas transceiver for all-band operation. The s.w.r. meter, removed from its case, is mounted in a hole cut in the lid of an aluminum utility box. The tuner is at the left. At the top of the panel is the miniature coaxial jack for the antenna line and below it are the controls for the tuner. From top to bottom: Output capacitor switch, output capacitor C2, inductor switch S2, input capacitor C1 and input capacitor switch. The whole unit is almost small enough to go in your pocket!

Doctor Liv smiled. "Pendergast's nearly forgotten about ham radio. He's been romancing Rosie Radiator".

Rosie Radiator? Isn't that the CB YL I saw him with a few times?"

"That's right", replied Doctor Liv. "Rosie and Pendergast have a thing going".

"Another good DXer falls by the wayside. Where's he going for his honeymoon?"

"You are a little premature", replied Doc. "Not until he gets his two meter gear installed in the car. I'm sure of that".

I looked up at the spring sunshine. "I'd like to be taking a trip, myself", I said. "Sometimes I envy my friend, Bill, K6VQ. He travels a lot and sees the world. And he takes his *Atlas* transceiver along with him".

"What does he do for an antenna when he hits some out-of-the-way place?", inquired the good doctor as he shifted about on the hard bench.

I reached in my jacket pocket and brought out some photographs and a schematic drawing. "Well, Bill has built up a mini-s.w.r. meter and antenna tuner. It had to be very small since he travels light. Look at this (fig. 1). This box, which measures only 6″ × 3½″ × 2″ has all the works in it. The schematic is fig. 2. Note that he makes use of a CB-type s.w.r. meter. He got his at a flea market for a dollar because the diodes in it were burned out. To the left of the s.w.r. meter are the controls for the pi-network matching circuit.

"This network is composed of a tapped coil and variable input and output matching capacitors. Bill was intrigued by the pee-wee imported mica-leaf variable capacitors used in miniature transistor radios, so he bought two of them and checked them out. As you see, they are only a little bigger than a postage stamp".

"Will they stand the gaff with a 100 watt transceiver?", asked Doctor Liv.

"Bill put over 500 volts a-c across the capacitors with no ill effects so he thought he'd try them out in actual service. And they worked just fine! He used two miniature switches to add extra circuit capacitance if he needed it. And a mini-coil and small rotary switch completed the network. He used inexpensive stereo fittings that match coaxial line. An inside view of the unit is shown in fig. 3".

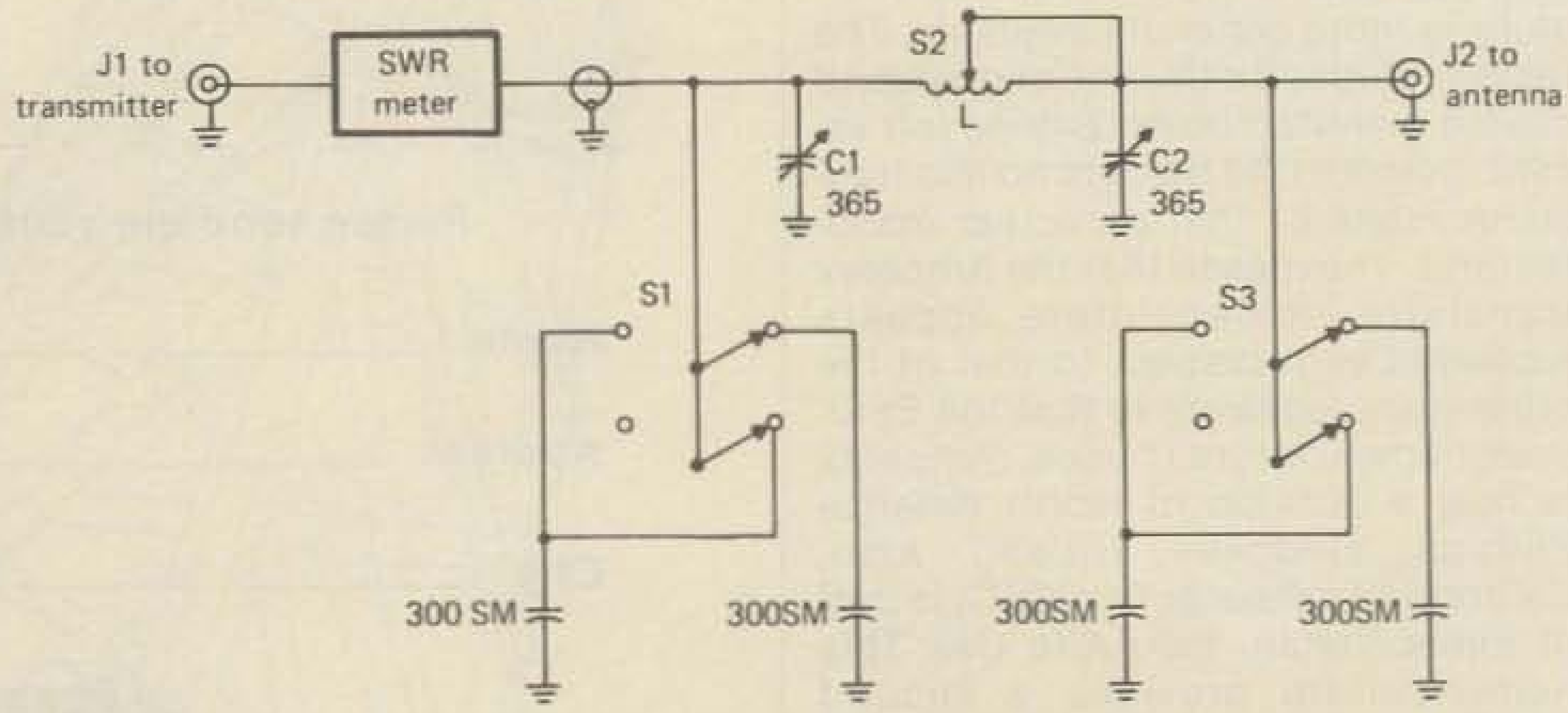


Fig. 2—Schematic of K6VQ Antenna Tuner
C1, C2—365 pF mica compression. Philmore 1951.
S1, S3—DPDT miniature toggle switch. C-H SF2BX191 (On-off-on).
S2—Single pole, 12 position, miniature silicone switch. Oak 399217A.

*83 Suburban Estates, Vermillion, SD 57069.

"Beautiful", said Doc Liv. He examined the device as if it was a fine jewel. "What kind of an antenna does K6VQ use with this match-box?"

"He uses a trapped, triband dipole for 10, 15 and 20 meters and a random length wire for 40 and 80 meters. As you know, the *Atlas*—as with other solid state transceivers—likes to work into a very low s.w.r. antenna load. The triband dipole, while an excellent performer on three bands, has a rather sharp s.w.r. repsonse. And this reduces the transceiver output because of the built-in protection circuit that reduces transmitter output as the antenna s.w.r. rises. You really need an antenna that is very flat if you want to operate a solid-state transceiver over more than a very narrow frequency range. And this little

Fig. 3—Interior view of the K6VQ mini-tuner and s.w.r. meter. At the left is the s.w.r. meter removed from its case. A home-made aluminum shield runs from top to bottom of the box and shields the s.w.r. meter from the tuner (at right). Placement of the coil and the two miniature tuning capacitors is visible at the center of the assembly, with switches S1 and S3 above and below the tuning capacitors.

matching unit does the job very nicely".

I handed the unit to Doctor Livingston. "Observe that K6VQ placed an aluminum shield plate running between the s.w.r. meter and the components of the tuning unit. Other than that, wiring is very straightforward".

"Tell me about the triband dipole", said Doctor Liv. "It would have to be small and light to go along with this unit".

"Right", I replied. "K6VQ decided to make up a very light and compact trap-style triband antena for 20, 15 and 10 meters. The dimensions are conventional (fig. 4). His assembly technique of the traps is interesting. The antenna is made up of insulated hookup wire, which is very flexible. Each trap is made up of a small air-wound inductor which is slid onto a short length of plexiglass which serves as a support for the coil and as tie-points for the antenna wires and capacitor.

"Bill wanted to use the smallest capacitor available, but little information could be found about the current and voltage impressed upon the capacitor in such a complex trap circuit. While the trap is a very simple device, its function changes with the band in use. And as far as I know, no mathematical treatment has been made of the actual trap operation. So Bill tried the hueristic approach....."

"Hueristic?", queried Doctor Liv.

"Cut-and-try", I replied. "He used a 1500 working volt, dipped mica capacitor for the 15 meter trap. And for the 10 meter trap (not being able to find enough proper values of capacitance) he used three 500 volt capacitors connected in series. After assembly, the traps were trimmed to the proper resonant frequency with a dip-meter. A photograph of the 15 meter trap is given in fig. 5. It is a very simple and light assembly.

"And for the coaxial line, it is possible to use RG-58/U. And for an even lighter assembly, you can use RG-174/U line, which is only 3/32" diameter. It has a little more loss than RG-58/U, but if the line is short it doesn't make much difference".

"Sounds very nice" said Doctor Liv as he returned the photographs to me. "Anything else of general interest that Pendergast is missing?"

"Yes", I replied. "There is a very interesting antenna described in *Radio Communication*, that excellent magazine of the Radio Society of Great Britain (1). It is in the *Technical Topics* column written by my good friend Pat Hawker, G3VA. The antenna was designed and built originally

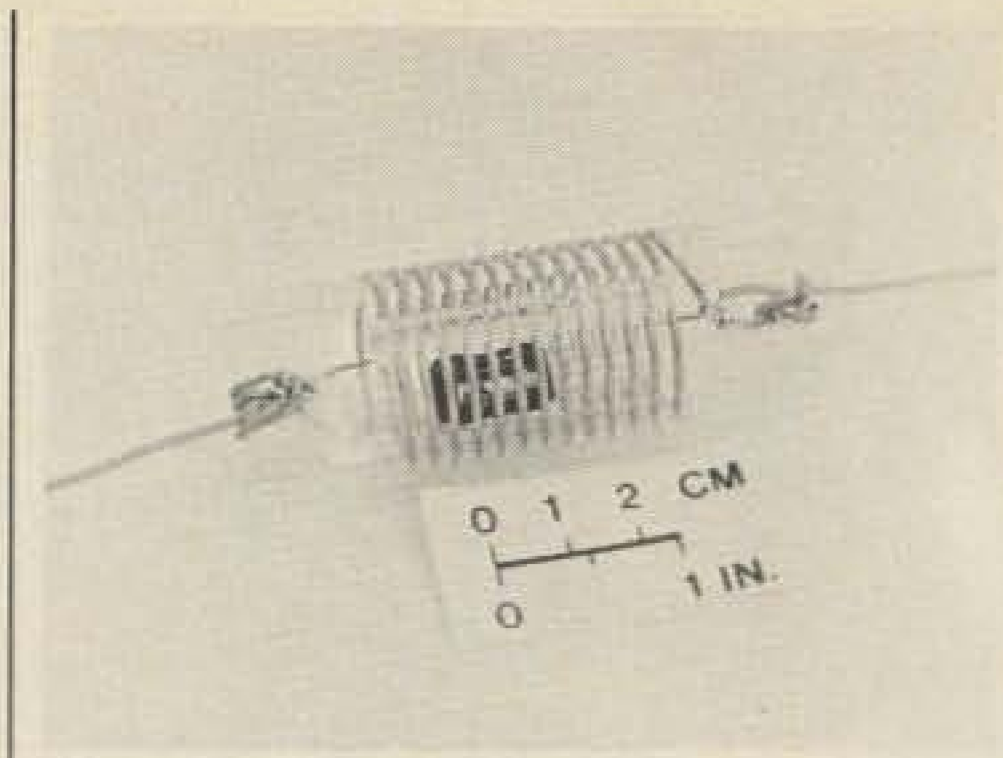


Fig. 5—The K6VQ mini-trap for 15 meters. The capacitor is a 1.5 kV silver mica unit. Overall trap length is about two inches. Trap is dipped to 21.0 MHz. on the bench before placing in antenna.

by UA3IAR, in Kalinin, U.S.S.R. It was written up in the Russian magazine, *Radio* in June, 1978. Basically, the UA3IAR antenna is a two element Quad array supported from a single pole (fig. 6). This is a Quad-type antenna that is fixed, requires no framework of self-supporting elements, yet can be remotely switched so that the main lobe falls in any one of four quadrants. Since the unidirectional pattern is about 90 degrees wide (between the −3dB points), this means that the array provides coverage through 360 degrees with no turning delay.

"The array is, in effect, a two element Quad with a fed-reflector. The array is formed from four half-loops which can be selected so that at any time two half-loops form the radiator and the other two the reflector. Four position switching provides the four basic configurations for unidirectional beams. In each position, two half-loops form the driven element, while the other two form the driven reflector with its phasing section of transmission line.

"Fig. 6 shows the antenna in comparison with a conventional two-element Quad. The upper vertices of the UA3IAR Quad are joined together, while the lower vertices form feed

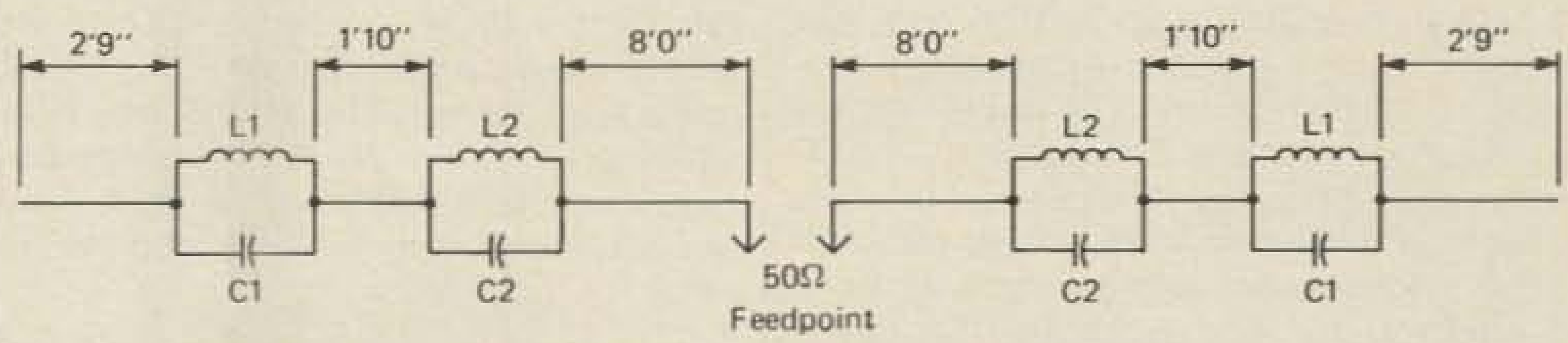


Fig. 4—Schematic of triband dipole for 20-15-10 meters

L1, C1—15 meter trap. 24 pF silver mica capacitor plus 2.3 uH coil. 14 turns, 1" diameter, 8 turns per inch. Adjust number of turns for resonance at 21.0 MHz.

L2, C2—10 meter trap. 24 pF silver mica capacitor plus 1.3 uH coil. 8 turns, 1" diameter, 8 turns per inch. Adjust number of turns for resonance at 28.0 MHz.

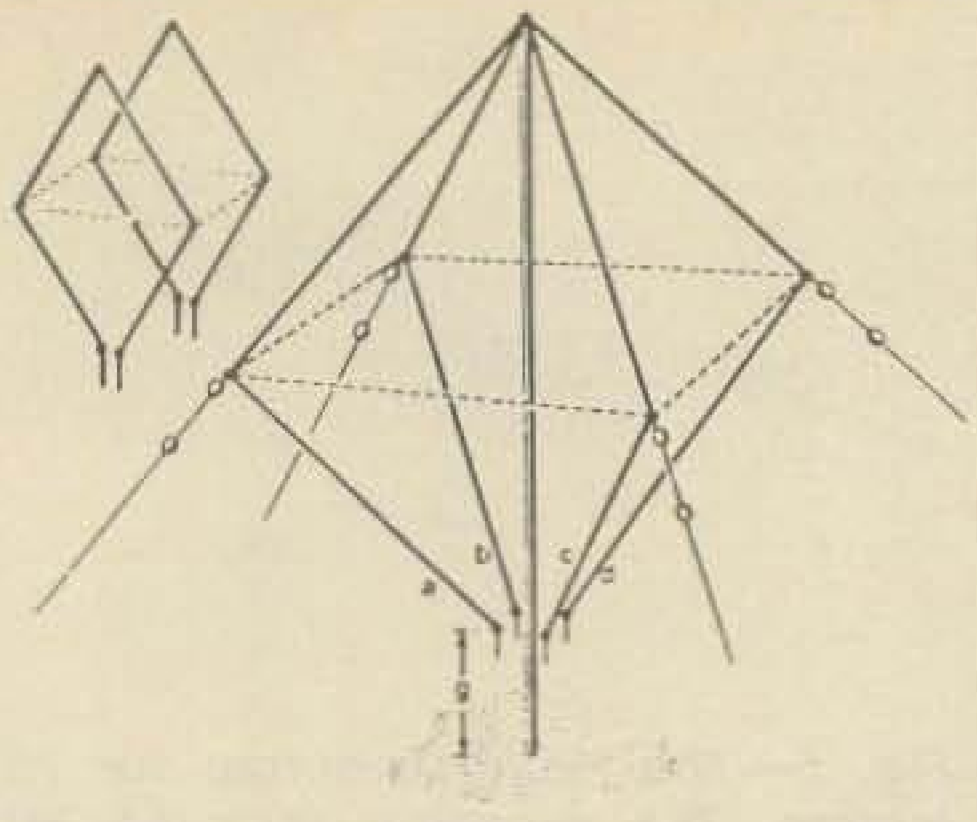


Fig. 6—The UA3IAR switchable Quad antenna for 20 meters. Development from a conventional Quad (left) is shown. The four half-loops abcd are electrically joined at the top, and pairs of half-loops are used to form the full-wave loops which function either as radiator or, with the additional phasing extensions, as driven reflectors (Drawings from "Radio Communication").

points. The middle portions of the loop are pulled out by guy wires. All wires, in fact, are held in place by guying rather than by a framework. And all wires are electrically connected together at the top of the array.

"The switching technique used by UA3IAR is shown in fig. 7. To form a unidirectional radiation pattern it is necessary to provide a suitable phase difference between the currents flowing in the two loops. This phase difference is slightly more than 180 degrees. The exact value of phase shift depends upon the effective spacing between the loops, with an initial phase difference of 180 degrees being obtained by suitable connection to the appropriate windings of the ferrite core transformer, T1.

"Extra phasing elements are connected into the loop forming the reflector elements, with all switching provided by relays RLA and RLB. The switching sequence depends upon the position of the selector switch, S1.

"As an example, in switch position 1 both relays are energized and winding L3 of transformer T1 is connected to half-loops *a* and *b* through the coaxial line phasing elements. In this fashion two complete loops (*ab* and *cd*) are formed with *ab* acting as a reflector. In this example, the beam direction is that indicated by arrow 1. Arrows 2, 3 and 4 correspond to beam directions of the three other switch positions. Four vacuum relays connected in pairs are used by UA3IAR. Contact rating of the relays is not important as no antenna switching takes place with power applied to the antenna".

"What about the ferrite transformer?", asked Doc Liv as he sketched the illustrations into his notebook with a graceful touch.

"According to the G3VA article, transformer T1 is wound upon two, stacked ferrite cores with windings made from three parallel wires. Winding L1 has ten turns; windings L2 and L3 have eight turns each. This particular antenna is fed with a 75 ohm coaxial line and the s.w.r. is stated to be less than 1.4-to-1 across the 20 meter band. I would imagine that it could be used with a 50 ohm line if the number of turns in winding L1 was reduced to seven or eight".

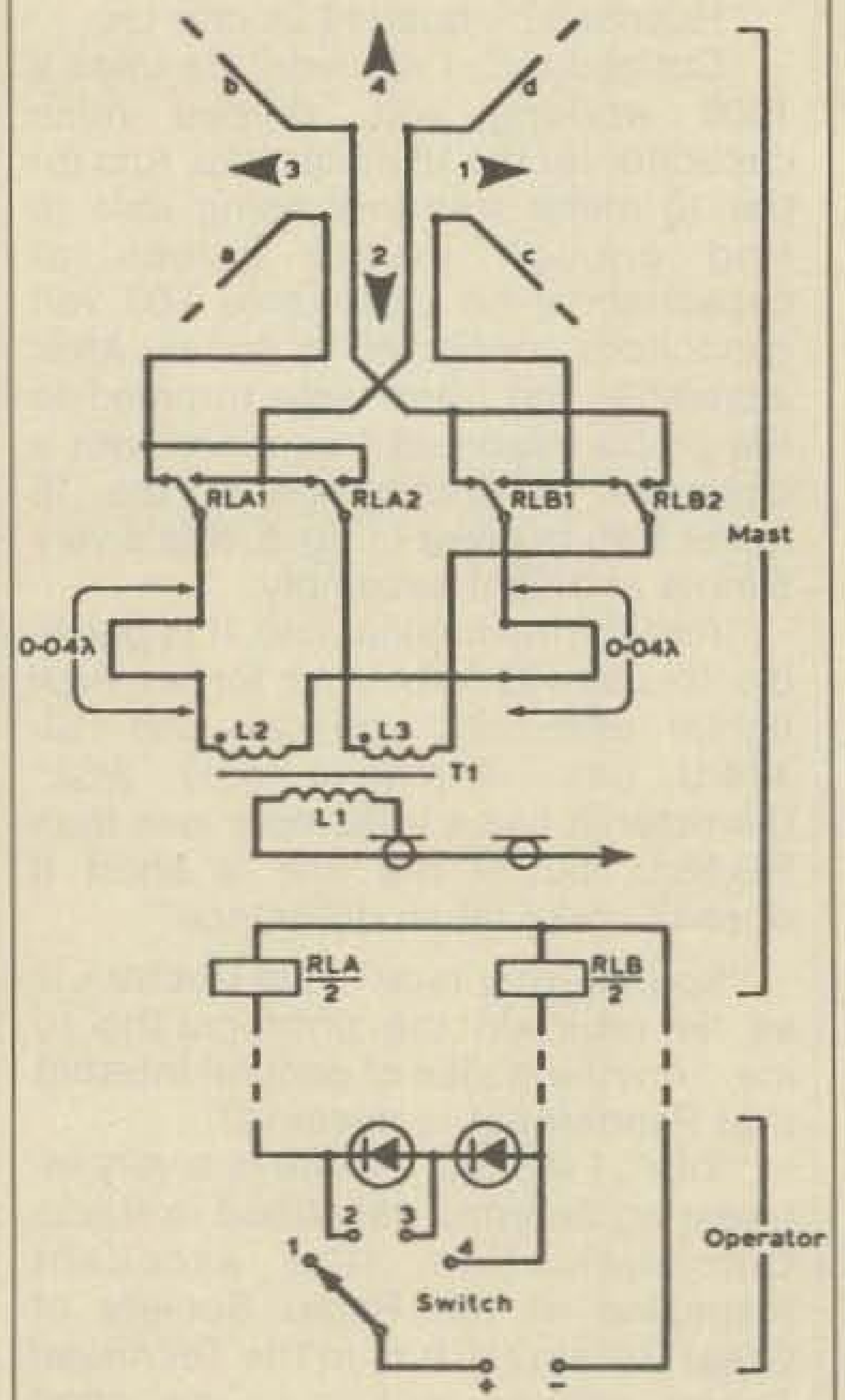


Fig. 7—The control and switching system. The two .04 wavelength extensions are used to provide a .08 wavelength phasing section to convert the appropriate loop into a reflector. T1 is a large ferrite core. Dots indicate winding polarity. In absence of relay energizing voltage the beam is set in direction 1. Note that diode between switch positions 3 and 4 is shown the wrong way. It should be reversed.

"How about the antenna dimensions?", asked my friend.

"Well, for 20 meters, a 30 foot mast is used. The length of each half-loop wire is 10.95 meters, or 35'10". Tests run on 2 meters by UA3IAR indicate that the optimum length of the half-loops is 0.53 wavelength and the optimum length of the coaxial phasing elements is 0.08 wavelength (total). Finally, the polar plot of the 2 meter model is shown in fig. 8. No information is given about forward gain in the original article, but G6XN, who is an authority on antennas in England, estimates the gain to be between 3 and 4 dB.".

"This seems to be a practical switched array for 20 meters and it is not complicated to build. I hope some of the readers of my column try this antenna out and see how it works!"

Doctor Liv got up, stamped his feet and swung his arms about. The air was not as warm as we thought and we both looked toward the shack door at the same time. "I suggest we go inside", I remarked.

Doctor Liv walked into the shack, which now seemed super-heated.

"How are the sales of your new antenna handbook going?"

"Great!", I admitted. "Nearly up to a second printing. I'm pleased to see it doing so well".

"That's good news to start out in 1979", remarked the Doctor. "Now, all we have to do is sit back and see what develops between Pendergast and Rosie Radiator. So you see, your problems are not all behind you".

Information on the UA3IAR Quad antenna is reprinted from "Radio Communication", *the publication of the Radio Society of Great Britain. For information on the magazine and membership data in the RSGB, write to the Society at: 35 Doughty Street, London WC1N 2AE, England.*

The new W6SAI handbook is entitled "The Radio Amateur Antenna Handbook", This 188 page book covers antennas from A to Z and is available from: Radio Publications, Inc., Box 149, Wilton, CT 06897. Price: $6.95 plus 50¢ postage and handling.

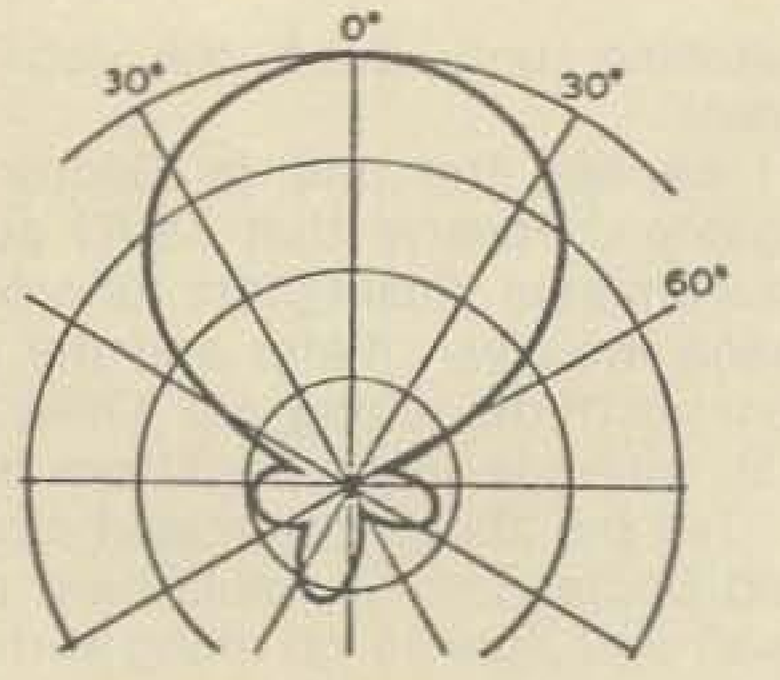


Fig. 8—Polar diagram of UA3IAR model antenna as measured on 144 MHz.

a monthly feature by

WILLIAM I. ORR, W6SAI

Antennas

Design, construction, fact, and even some fiction

"Thank goodness, summer is finally under way", said Pendergast as he tossed his sweater in a corner of the room. "Between snow, floods, lightning and a gas shortage, I am just about ready to turn in my DXCC certificate and take up stamp collecting".

"Not to worry", I replied. "We are coming into good weather and that means antenna time is upon us. And the bands sound so good it literally makes me itch to try some antenna experiments. Can I count upon your assistance in this manner?"

Pendergast yawned elaborately. "Certainly", he replied. "Just what do you have in mind?"

"This is the latest issue of *Radio Communication,*The journal of the Radio Society of Great Britian. I'm looking at an article by Bazley, G3HCT on the subject of DX antennas for 40 and 80 meters. Frankly, the high quality of the articles in this magazine amazes me. You should certainly subscribe to it if you want to keep up with modern design techniques.

"The article in question examines the knotty problem of how to get a good DX antenna for the low frequencies on a small lot. And G3HCT painstakingly tried a variety of antennas. He spent about five years in experiments on the air with his designs trying to develop an antenna having gain, a good front-to-back ratio, low angle radiation without requiring a big tower to support it".

"What did he come up with?", asked Pendergast, as he took out his notebook and pencil.

"The first antenna G3HCT tried was the popular inverted-V dipole with the center about 45 feet high. This seemed to work reasonably well to the U.S.A. but was relatively poor on long-haul skip to Australia, particularly on the long path.

"The next antenna tried was a quarter-wave ground plane using 60 radials buried just below the surface of the lawn. The long-haul DX situation was much improved, but short-skip work was considerably poorer than with the inverted-V.

"The third antenna tried was a trapped inverted-V for both 40 and 80 meters. Aside from the advantage of working on two bands the antenna performed similar to the first inverted-V, so it was eventually taken down.

"The next antenna was a combination of a ground plane and a trapped antenna (fig. 1). The wooden support pole is 45 feet high and the top section of the antenna is folded over. This arrangement worked well on both 40 and 80 meters and seemed to be effective on both short-skip and long-haul paths. Unfortunately, the radial system had been removed and the antenna was just working against

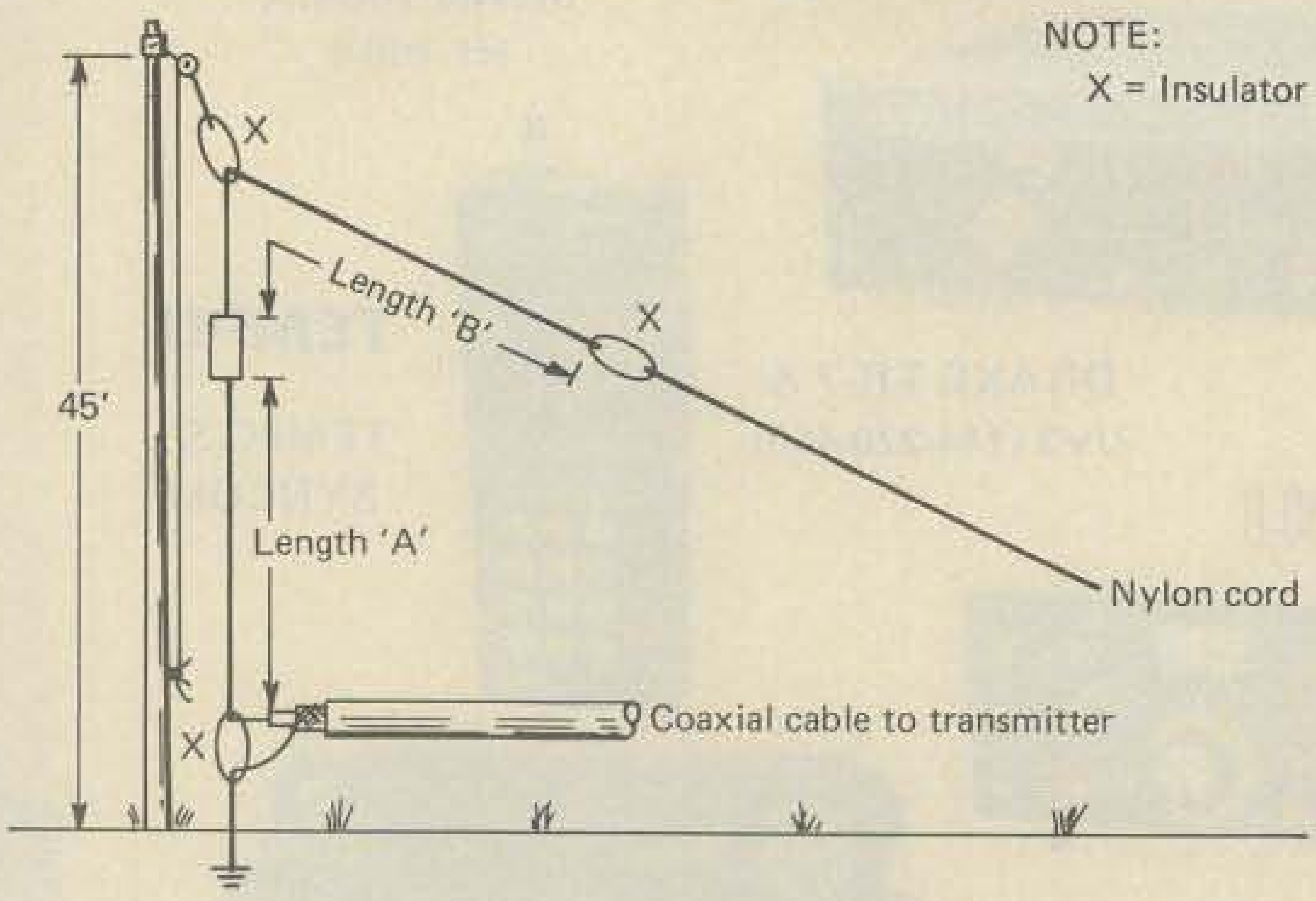


Fig. 1 - The trapped ground plane of G3HCT for 40 and 80 meters. Length A is 33 feet, length B is 29'3". The box represents a parallel tuned trap resonant at 7 MHz.

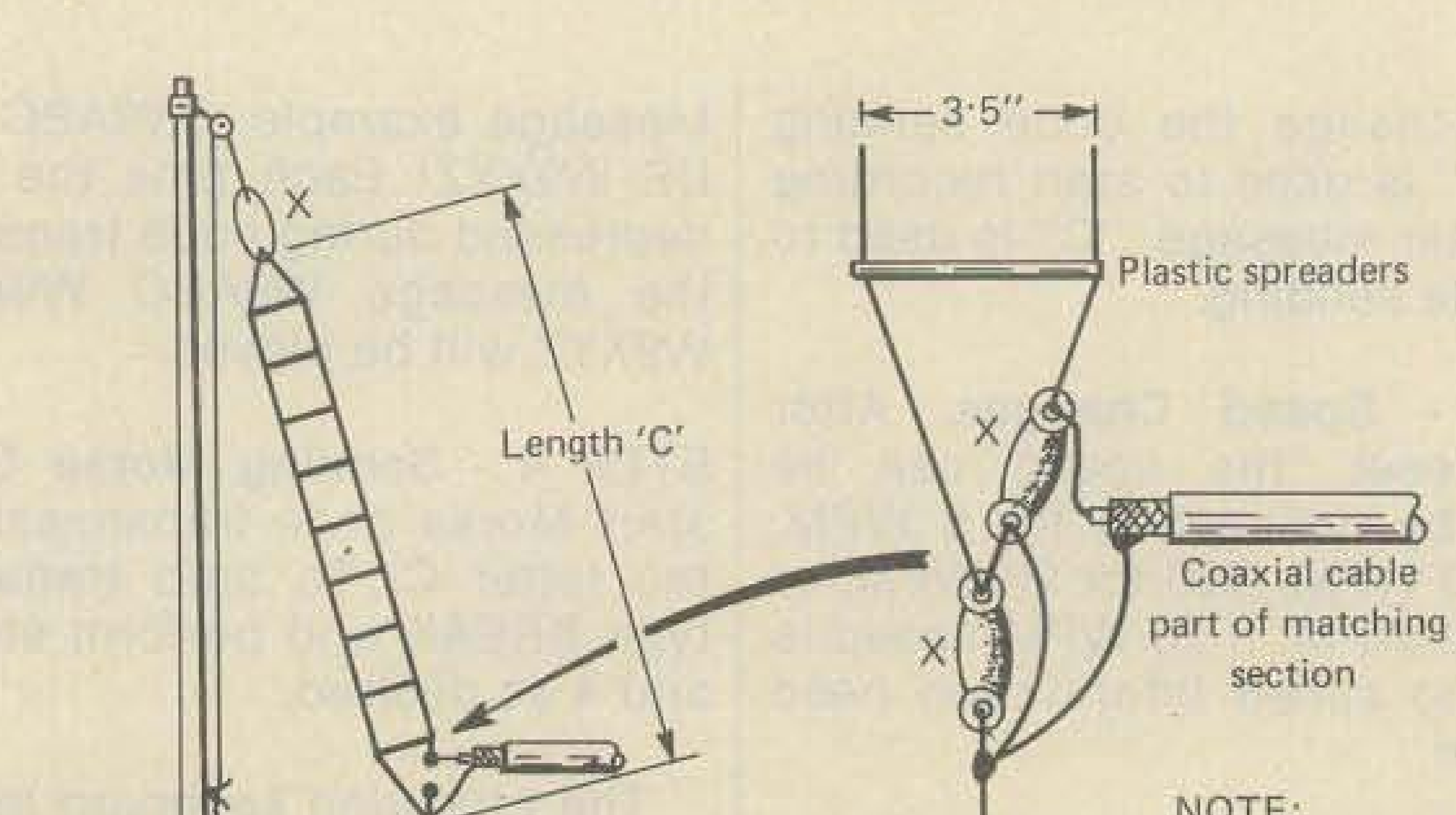


Fig. 2 - The vertical folded monipole at G3HCT. Length C is 34 feet.

48 Campbell Ln., Menlo Park, CA 94025

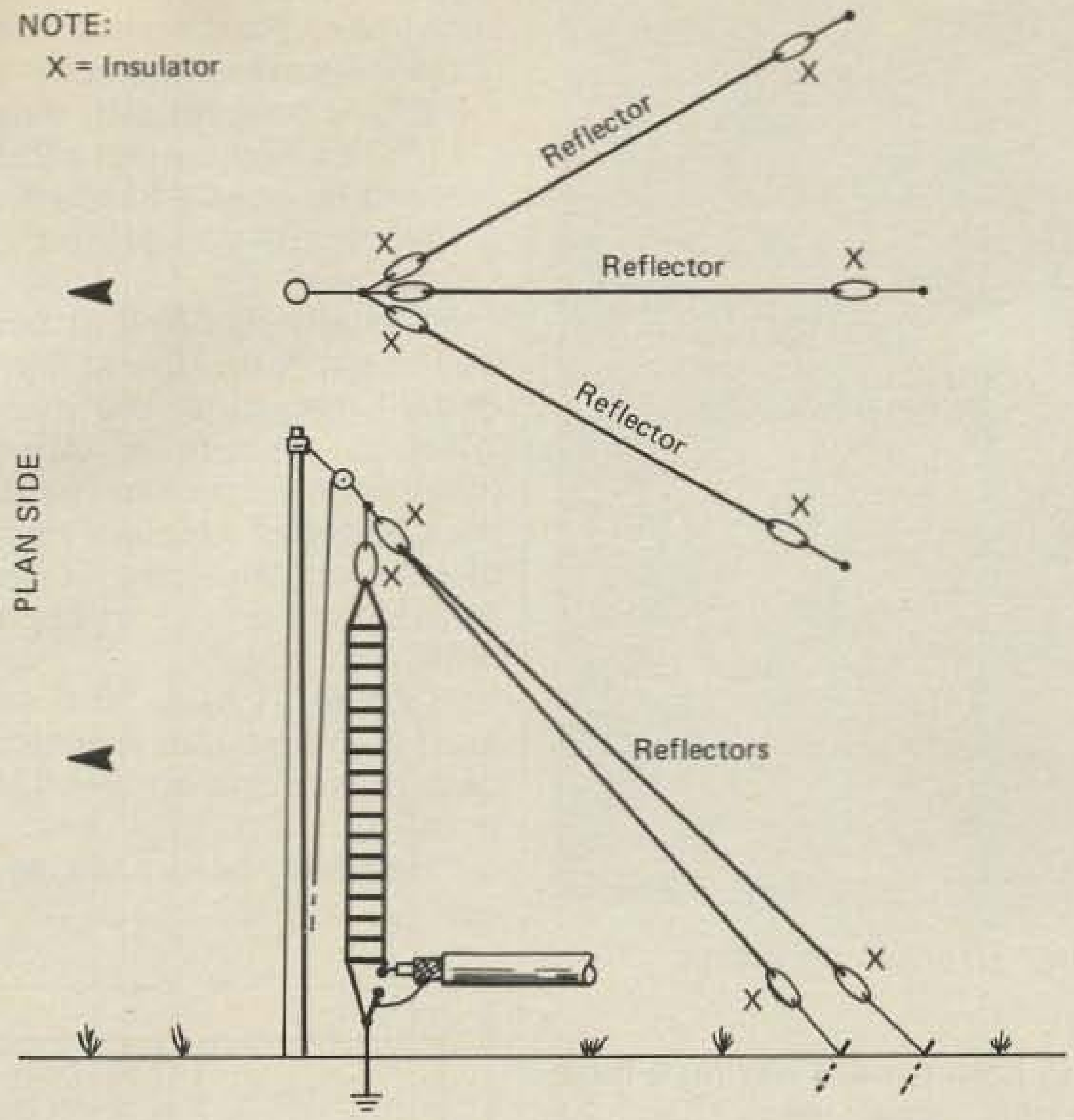


Fig. 3 - The G3HCT 40 meter beam. Length of reflector wires is 71 feet.

ground rods. The ground resistance reduced the antenna efficiency to about 50-percent.

"At this stage of the game G3HCT went back to a vertical antenna composed of half a folded dipole (fig. 2). The folded dipole multiplied the radiation resistance by four, raising it to about 165 ohms. This reduced ground losses to less than 5-percent and a definite improvement in both receiving and transmitting was noted over a period of time".

"Very interesting", commented Pendergast, but this is pretty much old hat. What happened next?"

"The next thing that happened was that a local amateur erected a two element Yagi at 60 feet for 40 meters. That proved to be the goad that spurred G3HCT to a final effort. He tried a phased vertical array which, after a lot of trouble and fussing, worked well and seemed to be competitive with the Yagi. However, the owner of the Yagi raised it to 120 feet above the ground which gave it a 2 to 3 S-unit advantage over the phased verticals.

"The final experiment was to place reflector wires on the vertical folded dipole (fig. 3). Reflector length was 71 feet and the reflectors were installed sloping down from the top of the pole towards the ground, as shown in the drawing. An excellent front-to-back ratio was achieved, and the simple antenna proved to be only a maximum of one S-unit down from the Yagi at 120 feet in the desired direction. G3HCT says, 'Without a doubt this is the best antenna I have used on 7 MHz'. And I say if you can compete with a 2 element Yagi at 120 feet, you must have a good antenna".

"Pendergast peered at the illustrations. "How did G3HCT match the antenna to a 50 ohm transmission line?", he asked.

"He used a stub system (fig. 4) that seemed to do the job quite nicely", I replied. "I like this simple beam antenna. It is inexpensive to build and, while it is not rotatable, it should do a good job in the chosen direction".

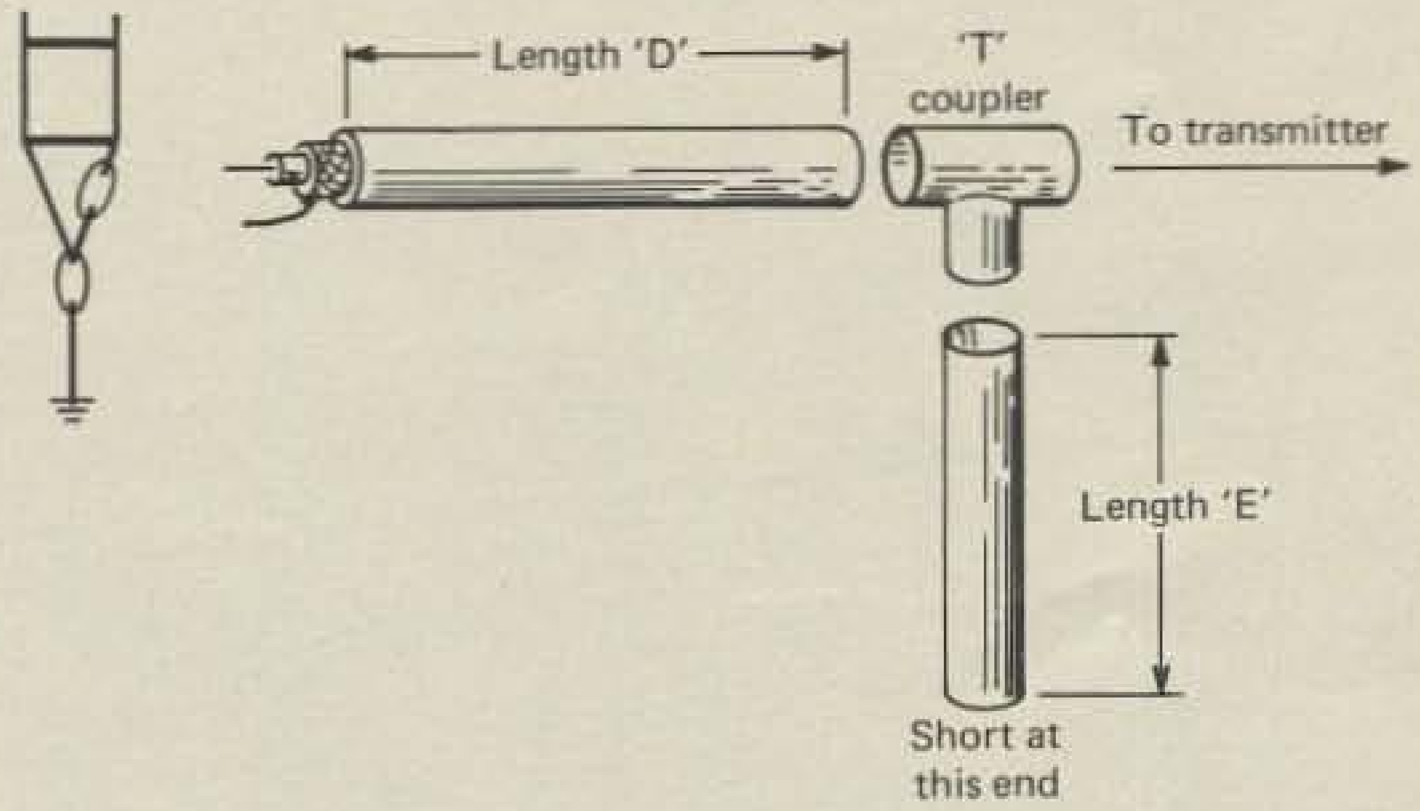
"My friend sighed, "Well, now that the bad weather is behind us, I would certainly like to get started on an antenna project. Maybe this is the one!"

"You are lucky", I replied. "Just look at these pictures of what the winter weather did to the big Quad at WB4JKZ (fig. 5 and 6). Pete has this Monster, 3-band Quad on a 32 foot boom. An ice storm hit it and the weight of the ice bent the bamboo and fiberglass spreaders. But, when the ice melted, it all came back in good shape, as you can see".

Pendergast shuddered. "I would hate to have to rebuild an array that big. Pete was certainly lucky". He reached into his pocket and handed me a letter.

"This came about a week ago and I forgot to give it to you. It is from John, N6JO, and outlines his experiments with the W6TC compact Quad loop discussed in the March column. John feeds the compact loop with a tuner and an open-wire line (fig. 7). The antenna is designed for 20 and 40 meter operation. Note the use of the open stub at the top of the loop. On 20 meters the stub acts as an open circuit and the loop resembles the X-array (expanded Quad). On 20 meters the stub is a quarter wavelength long and acts as a short circuit, closing the loop. There are 142 feet of wire in the loop, exclusive of the stub.

"John mounted the loop in the vertical plane atop his house on 30 foot masts made out of slip-up TV mast sections. The loop height was about 25 feet and the length about 92 feet. John reports good DX results on both



COAXIAL CABLE USED	LENGTH "D"	LENGTH "E"
50Ω RG8U	16'2"	9'3"
75Ω RG11U, solid inner	14'7"	11'10"
75Ω TV cable, semi air-spaced	19'	15'5"

Fig. 4 - The G3HCT network. Figures 1-4 courtesy of Radio Communication, an RSGB publication.

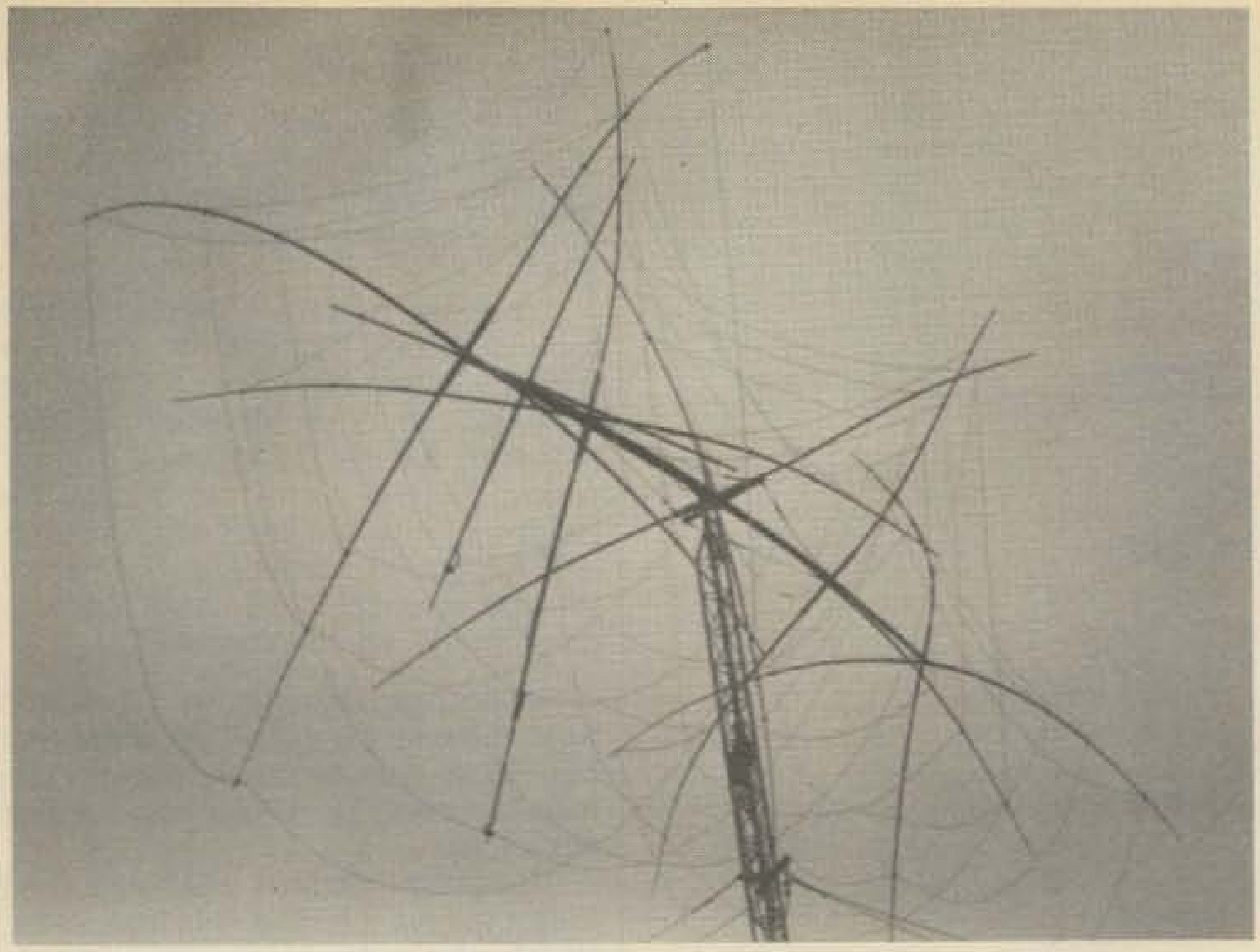


Fig. 5 - The "Monster Quad" at WB4-JKZ after an ice storm.

bands and is now experimenting with two loops driven 180 degrees out of phase, also with one driven element and the other as a parasitic reflector".

"Very interesting", I replied. "It is always nice to see fellows doing experimental work on their own".

"And here's something else", continued Pendergast, pulling a second piece of paper out of his pocket. "Now hear this. The Environmental Protection Agency (EPA) in Washington is considering a regulation to limit the height of all self-supporting ham towers having a base cross-section area less than 2.5 square feet to an overall height of 34 feet".

"Thirty four feet!", I exclaimed. "Why the height restriction?"

Pendergast continued reading, "It seems that free standing towers experience wind shear effects which shake the towers. It also seems that, especially in the late spring and summer, this shaking is transmitted to the surrounding earth. The vibrations disturb earthworms, causing them to come to the surface (often during the hottest part of the day). Exposure of the earthworms to the sun's direct rays causes them to die from sunstroke. Earthworms are very important facets of the ecology—hence the EPA's concern over the problem"

I looked Pendergast straight in the eye and he gently blushed.

"Where did you get that baloney?", I demanded.

He laughed. "Well, it came a long way to get here. I found it in "*Amateur Radio*" magazine, the journal of the *Wireless Insitute of Australia*, and they reprinted it from the bulleting of the *Cascades Amateur Radio Society* of Jackson, Michigan. The caption the Aussies put on the article is "Pull the other leg, Mate".

"I agree", I said. "But some of the stuff coming out of Washington these days makes one wonder if this may be true."

"However, before we wrap up this

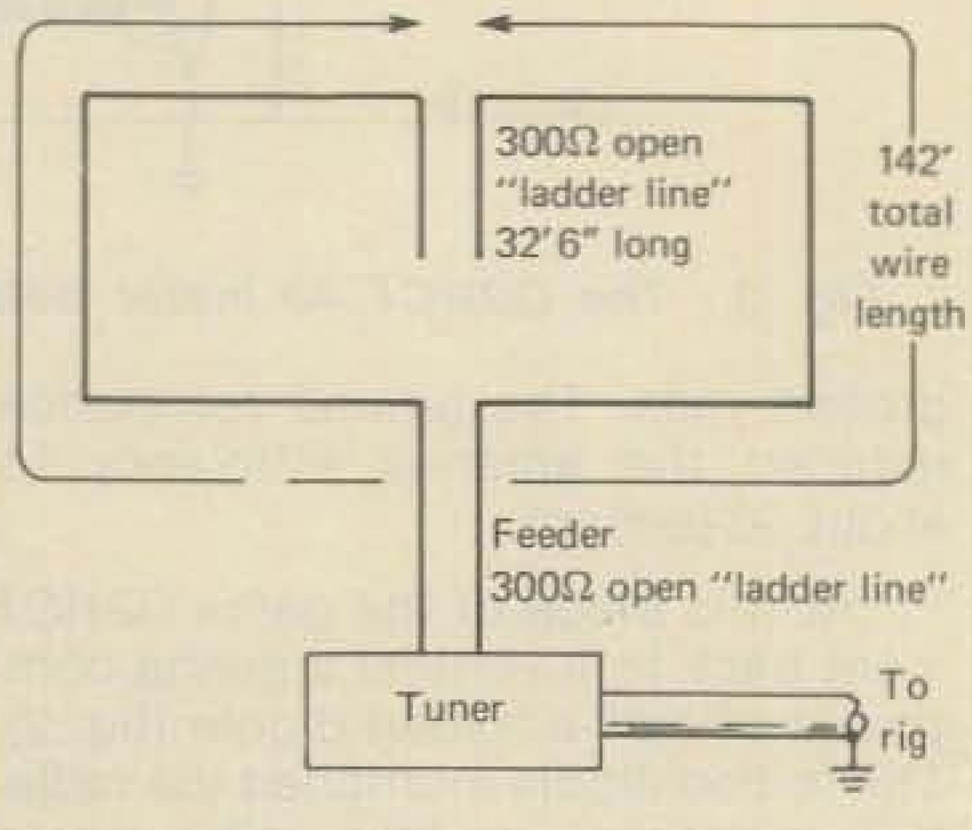


Fig. 7 - The N6JO version of the W6TC compact quad loop. Antenna is designed for 40 and 20 meter operation. John's feedline is about 16 feet long, but other lengths may be used. Loop dimensions are 25 × 92 feet.

session, I think you might like to look at the simple antenna tuner that Bill, WD5HOH is using to feed an end-fed wire about 45 feet long. He works on 40 meters with only 15 watts and he needed an "invisible" antenna. He took a tuner from the 1966 *ARRL Handbook* and modified it, as shown in fig. 8. He doesn't have a SWR meter so he made a field strength meter out of a *Simpson 260* analyzer. All he does is tune for maximum voltage on the 260. He uses a four foot ground rod in conjunction with several 40 foot radials buried about 2 inches below the soil. So far, as a new General he's worked over 30 states and Canada with his "invisible" antenna and his tuning network. If you can work that kind of stuff with 15 watts, the antenna must be *good*".

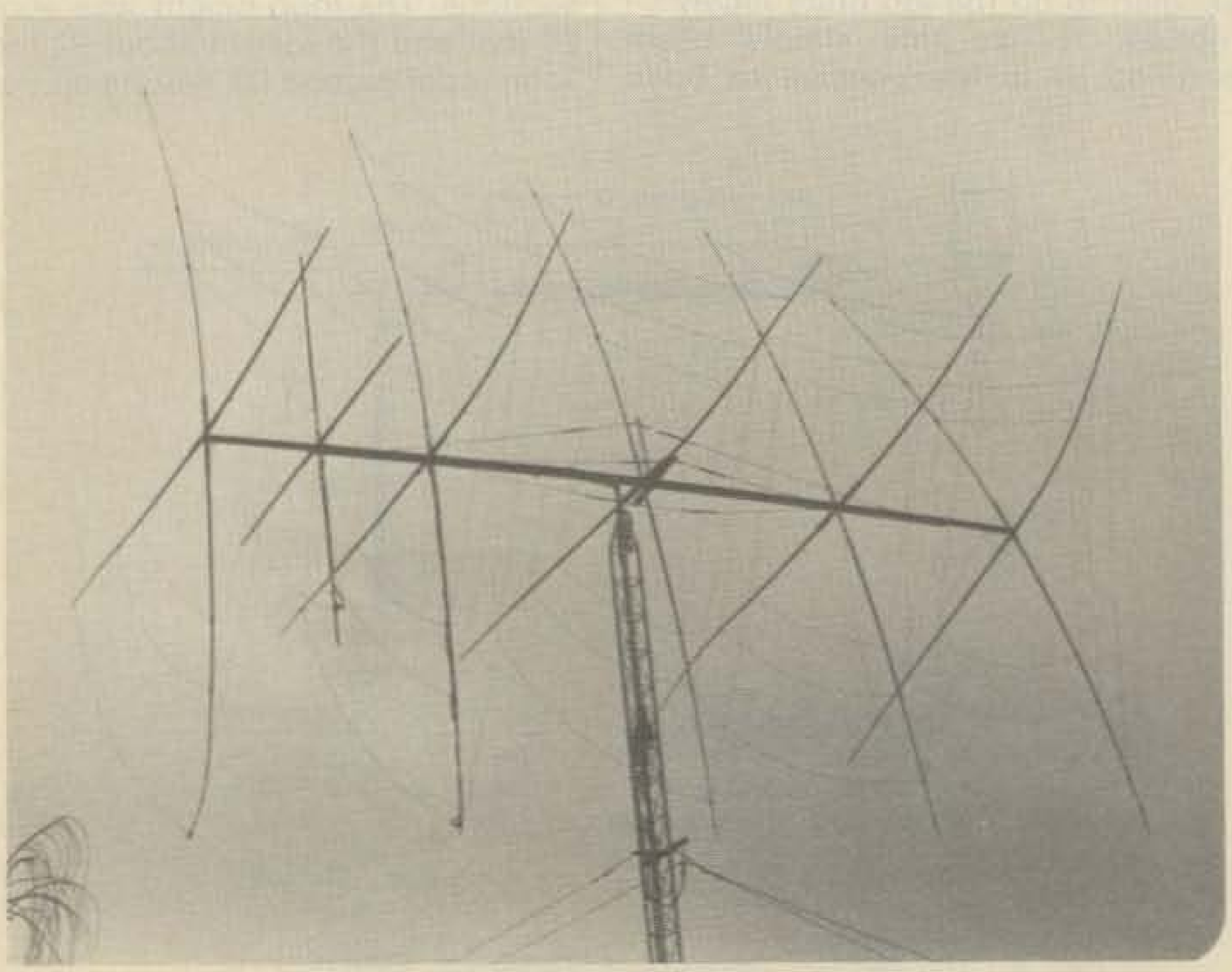
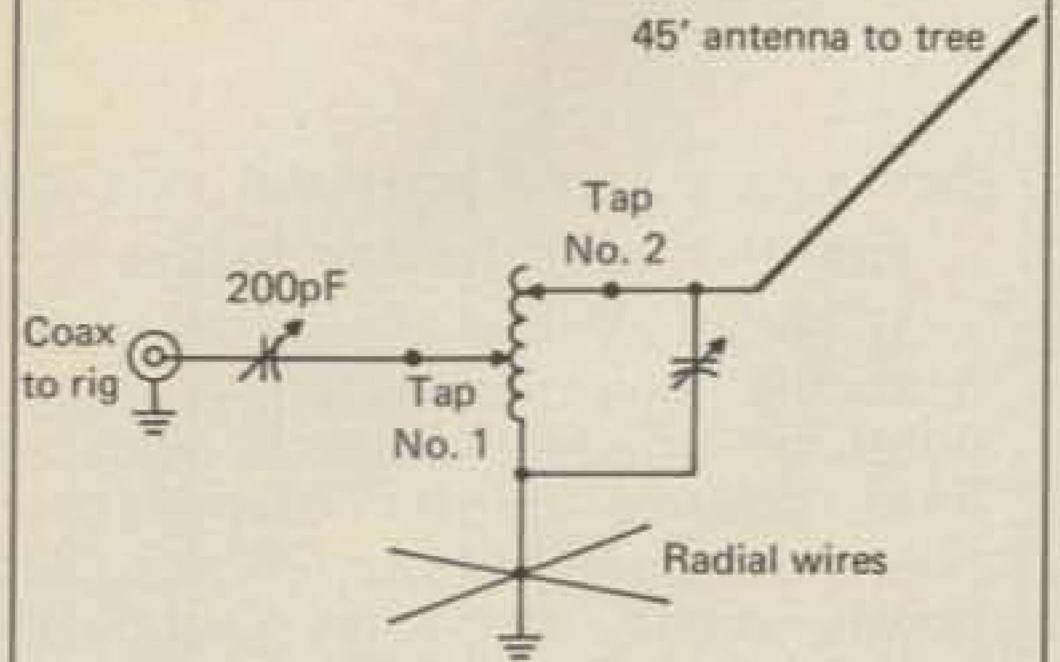


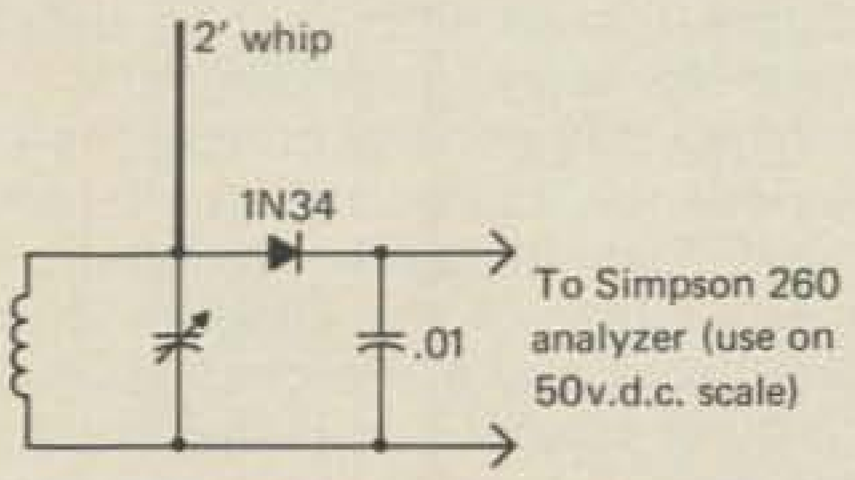
Fig.6 - Once the ice melted, WB4JKZ's quad returned to original shape.

"Very nice", replied Pendergast. "Tell WD5HOH that I can't punch my way out of a paper bag on 40 meters. How does he hear anything through the foreign broadcasters and the jammers?"

"Beats me", I replied. "I think it just proves the old saying that DX is 10% station and 90% operator".

Pendergast prepared to leave. "I have a schedule coming up in a few





FIELD STRENGTH METER

Fig. 8 - The simple antenna and turner at WD5HOH. Coil is 25 turns #16 wire spaced wire diameter on 2" diameter form. Tap 1 is 12-15 turns from ground end, tap 2 is 16-20 turns from ground end. A simple field strength meter is located at operator's desk.

minutes on 10 meters", he said. "So I'd better push off".

"You can work it from here", I offered. Again, Pendergast blushed. "Well, it's with Rosie Radiator. She's working mobile now and I'd just as soon do it from home".

"Suit yourself", I replied. "I'll just listen in!" (Note): W6SAI's new antenna book, "The Radio Amateur Antenna Handbook" is available from Radio Publications, Inc., Box 149, Wilton, CT 06897. This 188 page Handbook covers antennas of all types in simple, understandable language. Price: $6.95 plus 50¢ for shipping and handling.

* * *

The information on the G3HCT beam was taken from "Radio Communication". For more information on this publication, write to the Radio Society of Great Britain, 35 Doughty Street, London, WC1N 2AE England. A highly recommended publication!

a monthly feature by

WILLIAM I. ORR, W6SAI

Antennas

Design, construction, fact, and even some fiction

Pendergast kicked open the door to the shack and entered, carrying a bulky envelope in his hand. He handed it to me and sat down at the operating position.

"How are you and Rosie Radiator getting along?", I asked. Pendergast blushed slighted and replied, "Oh, just fine. Especially since she has given up CB radio and is studying for her ham ticket."

"Didn't you try to make a radio ham out of your old girlfriend, Bella Amtrak?", I asked as I opened the envelope. A handful of photographs slid onto the table.

Fig. 1 - The "Monster Quad" of W5MOK folded over for maintenance. This array has seven elements for 10, 15 and 20 meters on a 62 foot boom. A stepladder on the roof of the house allows easy maintenance.

"Yes, I did", replied my friend. "But she seemed more interested in model railroads, so I gave up."

"Better luck with Rosie", I said. "Maybe you can get her to help you put up your new Quad antenna."

"Yes", said Pendergast eagerly. "I'm most anxious to see these photographs from the boys in Cow Town (Fort Worth) that Don, K5DUT sent you. Suppose you hand them over."

"Here's the first one. It shows the Monster Quad of W5MOK that has been folded down for maintenance. The Quad is built on a 62 foot boom (fig. 1) and has seven elements on 10, 15, and 20 meters. The tower is a reinforced Rohn job. And fig. 2 is a closeup showing how Bob does his work on the antenna, standing comfortably on his rooftop. Very neat, isn't it?"

"I like that", breathed Pendergast as he absorbed the pictures.

I handed Pendergast another photograph (fig. 3). "This is a very nice shot of the Quad at W5VGE. This is built on a 52 foot boom, two inches in diameter. The array has six elements on 10, 15, and 20 meters. It is top-guyed at four points because of the small diameter of the boom. It is an unusual design in that it has two reflectors and an average front-to-back ratio of better than 40 dB. It is mounted atop a 71 foot *Tristao* tower. As far as I know, this is the first Quad design having two reflectors, and it looks as if the idea is sound. Most Quads have a rather poor front-to-back ratio, averaging about 15 dB. Maybe 20 dB."

I passed another photograph to my friend (fig. 4). "This is a shot of the six element Quad at WB5NJK. More accurately, it is six elements on 10 and 15 and five elements on 20. Boom length is 48 feet and is constructed of 3" diameter aluminum tubing having an .09" wall thickness. It is top-guyed at two points along its length. The antenna is mounted on a 55 foot *Rohn* tower."

Pendergast sighed. "I'd hate to compete in a pile-up with those fellas."

Fig. 2 - W5MOK working at roof level on his "Monster Quad".

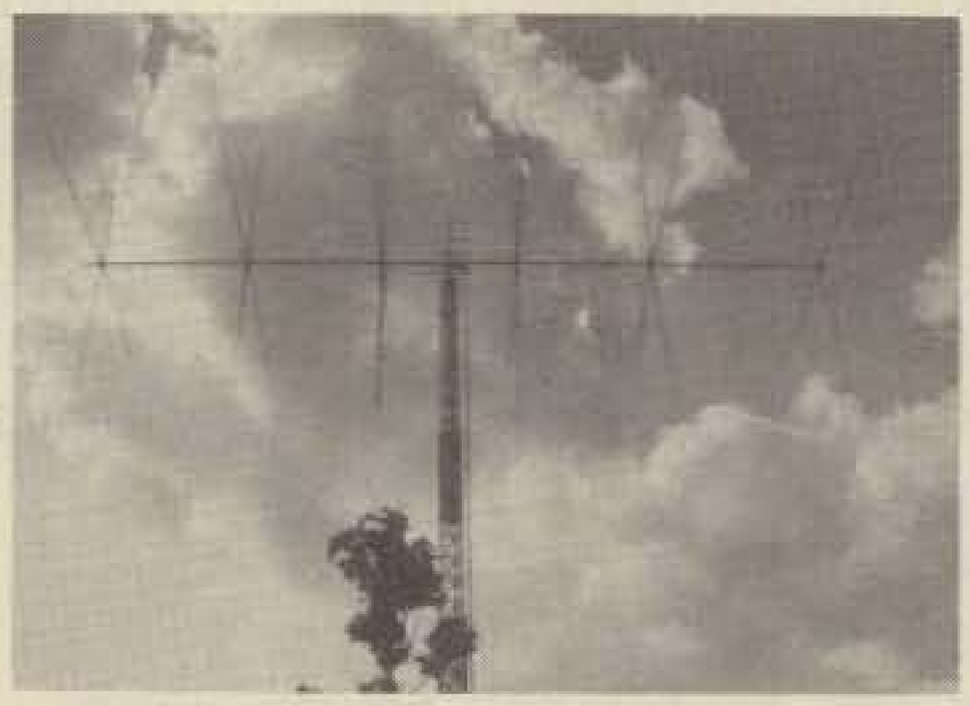


Fig. 3 - The "Monster Quad" of W5VGE. Six elements on a 52 foot boom atop a 71 foot crankup tower.

"Here's a shot of the multi-element Quad at N5UN (fig. 5). He has it up at 80 feet. He's got 7 elements on 10 meters, 4 on 15 meters and 4 on 20 meters. He said this Monster Quad is 2 to 3 S-units better on 10 meter DX contacts as compared with his old 2 element Quad at the same height.

"And Don reports that WA5FWC now has two 120 foot towers up and is building Quads for them. And here's a picture of Gary holding one full-size 40 meter Quad element (fig. 6). He's shooting for four elements on 40 meters!"

"They're all mad in Fort Worth", asserted as he looked at the pictures with an envious eye.

I picked up Don's letter. "Don says that W5MOK has just finished an experimental 5 element Quad on a 60 foot boom and says it is as good, or better than, his older 6 element job on a 52 foot boom. That's on 20 meters. But on 15 and 10 meters, Bob reports that results are not as good as the old antenna, probably because the spacing between elements is too great. Bob also says the 64 foot boom is difficult to keep up and he's decided to go back to the 52 foot boom with six elements on it. He's found lots of mechanical problems with the longer boom and doesn't think the extra gain on 20 meters is worth the effort, not to mention the loss of gain on 15 and 10 meters.

"Here's a photograph of Bob on the

*48 Campbell Ln., Menlo Park, CA 94025

tower (fig. 7). If your eyes are good and CQ's printing is clear, you can see the side guy wires on the boom and the arm on the tower that absorbs turning torque of the rotor and brake system."

Pendergast grabbed a picture out of my hand. "Hey, look at this", he shouted. "I always thought that K5DUT was a figment of your imagination. But here he is! Operating the Big Gun at N5UN!"

I looked at the photograph (fig. 8). "Where's the key?", I demanded.

"It must be a phone contest", replied Pendergast. "And look at *this*! Heresy!"

Pendergast handed me a photograph of a Yagi antenna (fig. 9).

"Don is building up an eight element Yagi on an 82 foot boom! He's going to try it out against one of the K5DUT Quads. The design will be for 20 meters. Then, if he likes that, he's going to shift over to *eleven elements* on 10 meters. That should bore a hole through the QRM. But I must admit that I'm surprised that K5DUT is going over to the enemy's camp and erecting a Yagi antenna".

"Them Oklahoma Dudes is full of a lot of tricks", observed my friend. "Don notes that W5VGE is putting up a new wide spaced, four element, triband Quad; Frank, WA5WRV, has just finished a wide spaced 20 meter Quad for his 120 foot tower; and K5LP is busy building a four element Quad. K5LP, Lanny, says there is no comparison between a trap, triband Yagi and a four element Quad. The Quad runs rings around the trapped Yagi. And, finally, Don says that most triband Yagis in the Fort Worth area are coming down and are being replaced with Monster Quads. He says that a tribander Yagi is a good beginner's antenna, but it can't compare to a BIG, Oklahoma-sized Quad antenna!"

I sighed. "It's tough to be loud on a small city lot", I replied. "But the Fort Worth gang certainly have proven the effectiveness of the big Quad. Don says that many DXers with big Yagis have been surprised by the ability of the Monster Quad to receive better and to transmit a stronger signal to a far away DX spot and to do it from a modest height."

I handed Pendergast another envelope. "All the news is not good. This letter tells me that W9LZX, Clarence Moore, the inventor of the Quad antenna has become a Silent Key. He passed away in early February. Clarence was a wonderful fellow. We have had many long, interesting QSO's on the air about Quads, and plenty of telephone calls and letters back and forth about some of his interesting antenna designs.

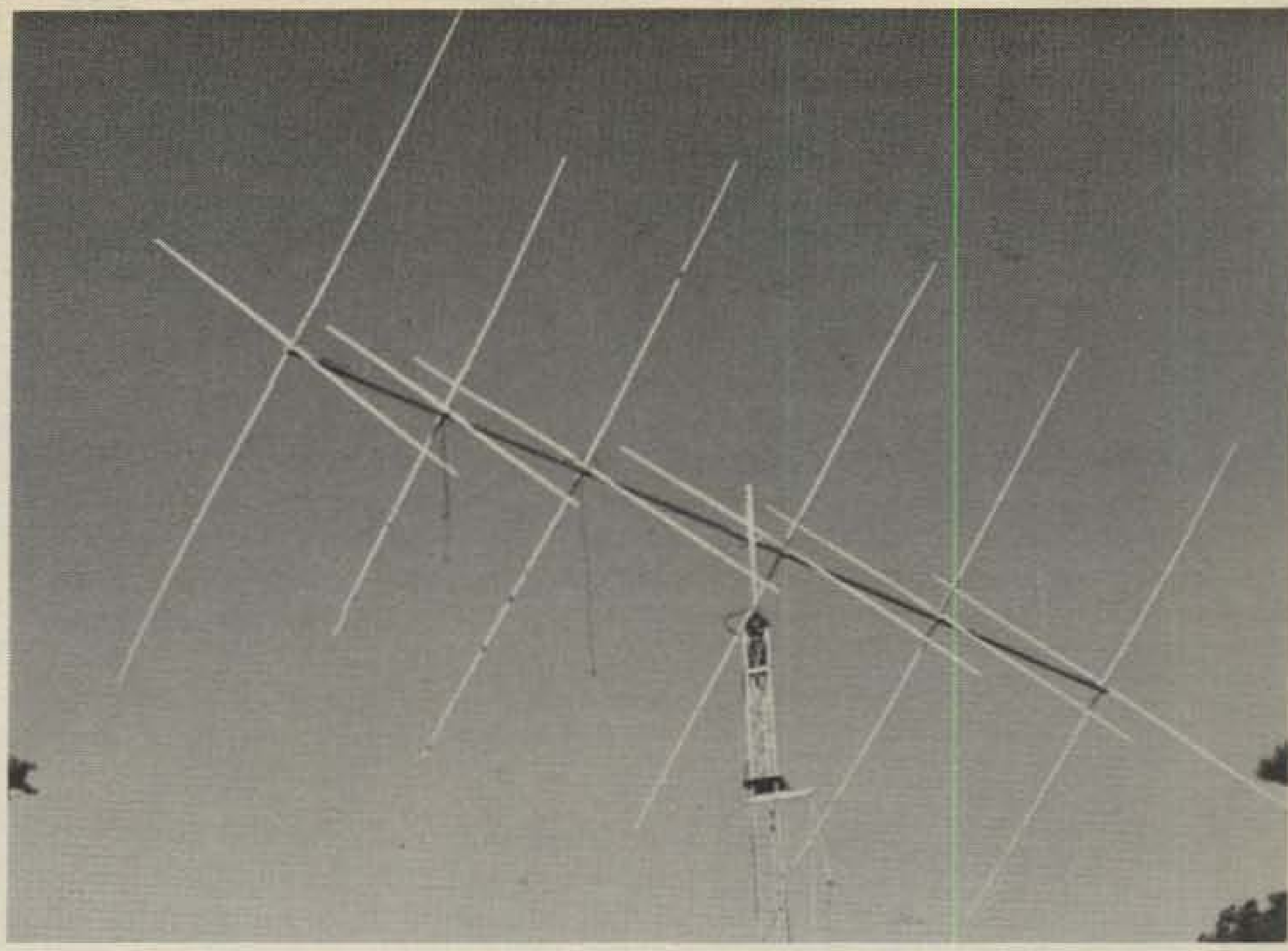


Fig. 4 - The six element "Monster Quad" at WB5NJK. Boom length is 48 feet supported 55 feet in the air.

Amateurs Radio has lost a close friend and enthusiastic operator.

"He was certainly a far-sighted antenna designer. Clarence pioneered the Monster Quad and, of course, was the original inventor of the Quad in the early "forties". Amateur radio will remember him for a long time."

"Yes", replied Pendergast. "The Quad was a truly original design and W9LZX was one in a million." He got up from the operating chair and prepared to leave.

"Before you push off, you might be interested in looking at a new topband antenna that Mel, K6KBE, of *KLM Electronics* has just finished. It is a vertical for 160 and 80 meter work. The bottom of the tower is made of aluminum tubes, four inches in diameter, .093 wall thickness and 36 feet long. Cast aluminum ring clamps are used to attach the two-inch diameter cross-braces. All sections are cross-guyed with 1/8-inch aircraft cable.

"The center section is made of 3-inch diameter tubing, .050 wall thickness and 55 feet long. And the

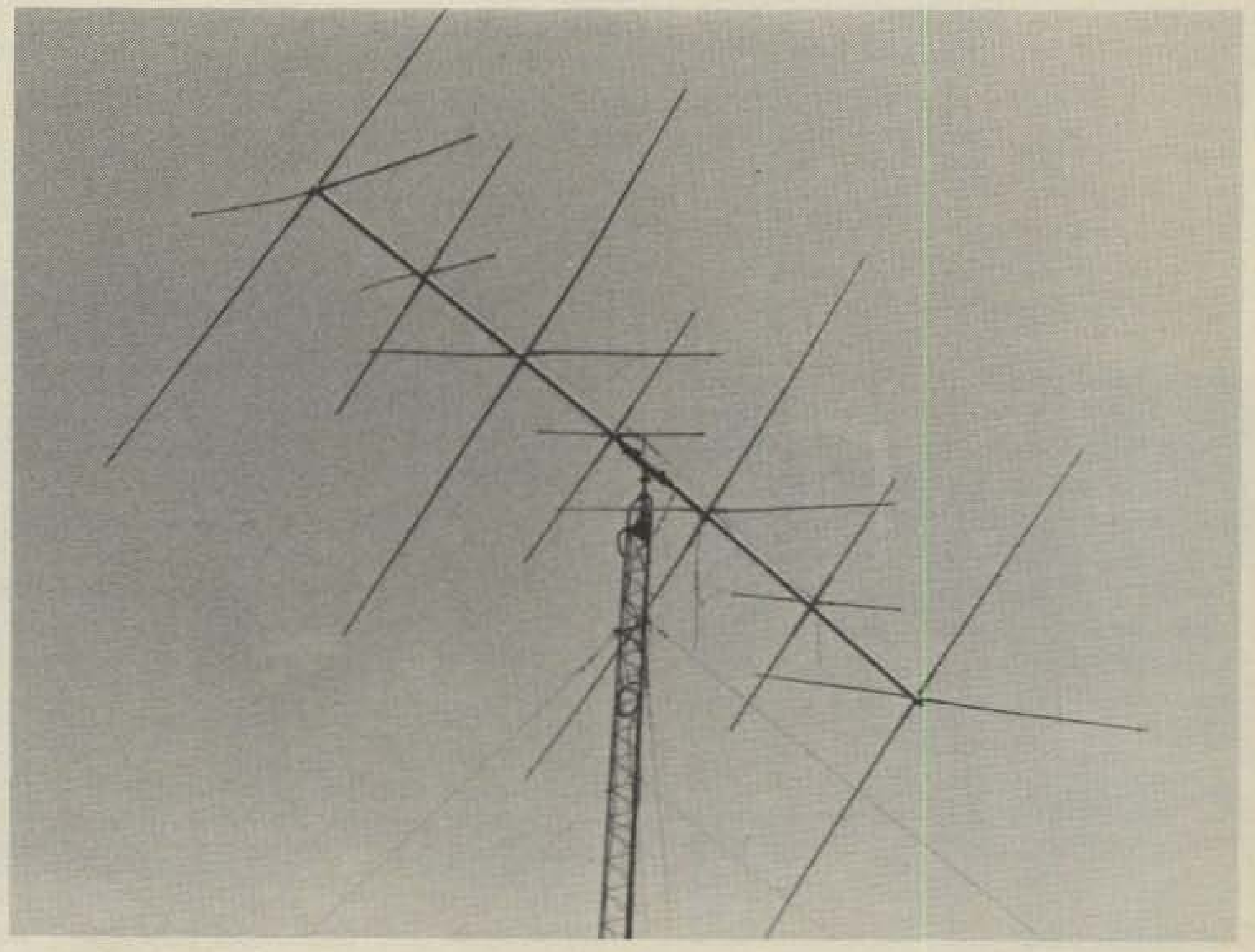


Fig. 5 - The multi-element Quad at N5UN. Seven elements on 10 meters, 4 on 15 and 4 on 20 meters.

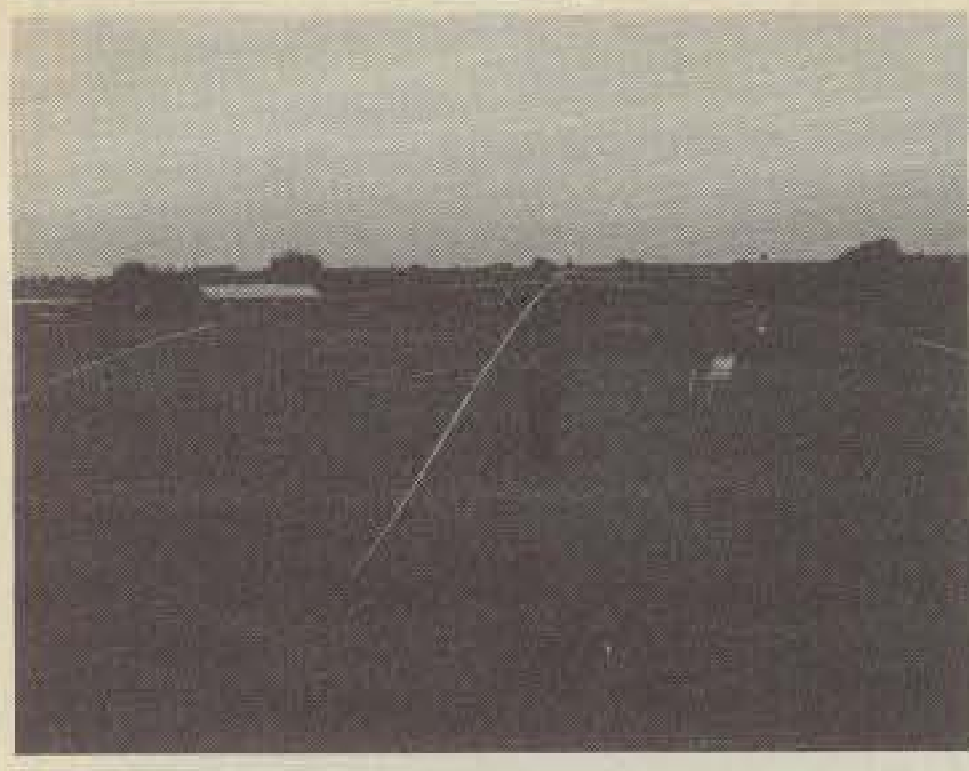


Fig. 6 - Gary, WA5FWC, supports a full-size 40 meter Quad element for his new beam.

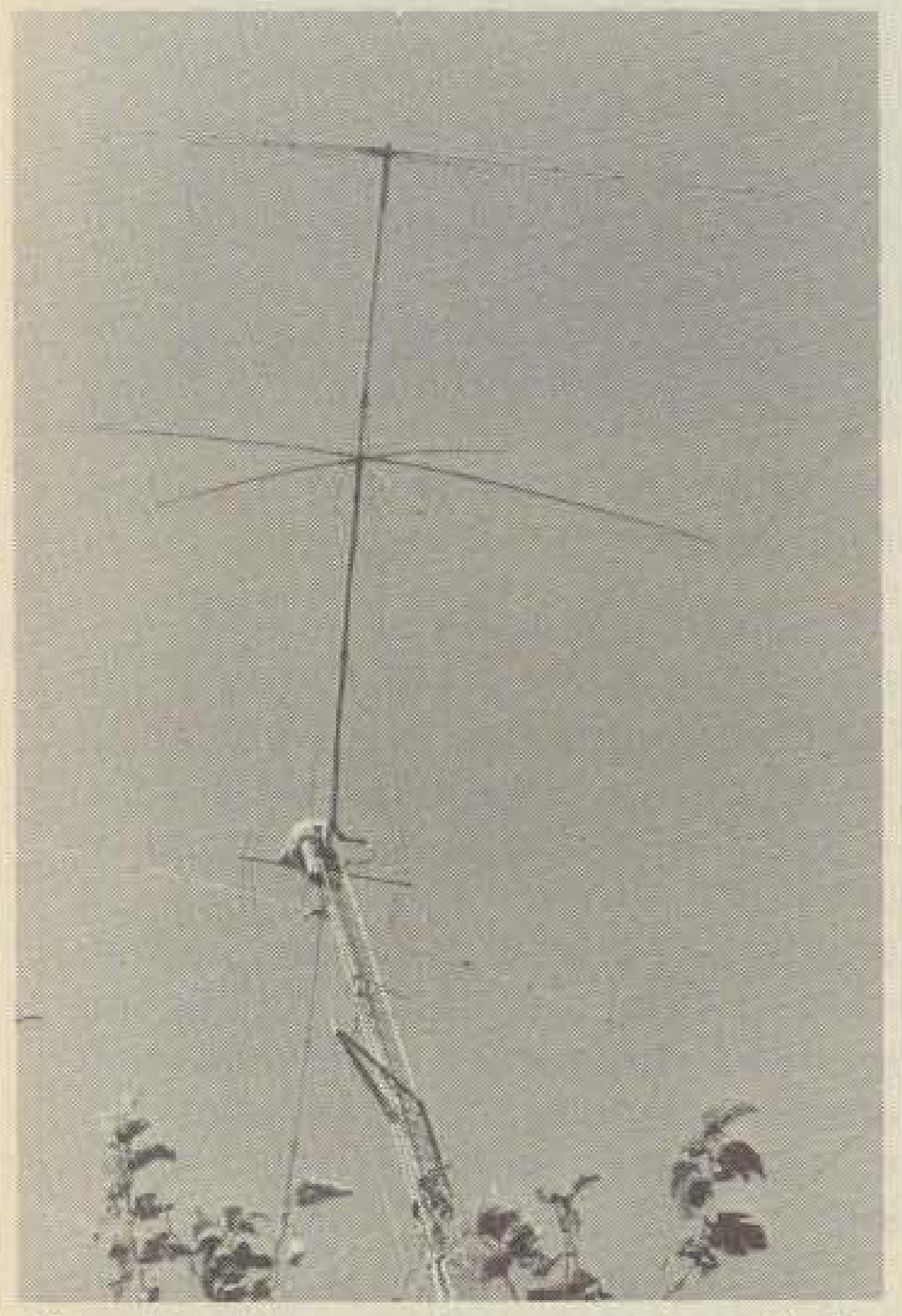


Fig. 7 - A worm's eye view of the "Monster Quad" at W5MOK. Bob is atop the tower. He's built Quads as big as will fit on a 64 foot boom but reports mechanical difficulties.

Fig. 8 - Don, himself! K5DUT operating at N5UN.

top section is telescoping, from 2-inches in diameter down to 1/2-inch in diameter. It is 55 feet long (fig. 11).

"The tower took about 80 hours to build and only 10 minutes to put up! It took a crew of four: one to supervise, one to drive a four-wheel truck which pulled the rope, and two on stabilizing ropes. A 36 foot gin pole was used, with a two point rope attachment to the tower, one at the 40 foot level and the second at the 88 foot level. A compound block and tackle did the job.

"The vertical antenna is insulated from the ground by fiberglass plates which fasten the tower to the base (fig 12). A yard of concrete is used and the mounting assembly is made of angle iron. The tower measures 12 feet across at the base and is 137 feet high.

"Antenna resonance with 23 radials is 1815 kHz. and covers up to 1900 kHz. with a very low value of s.w.r. The antenna can also be fed in series with a parallel tuned tank circuit at the base for 80 meter operation. And during the first few days of operation on 160 meters, very good reports have been received from New Zealand and the east coast. Figs. 11, 12, and 13 show closeups of the tower."

"Now, that's a *real* DX antenna for 160 meters. And no guy wires", exclaimed Pendergast. "It should be a blockbuster for the coming DX season!"

"Yes", I agreed. "And do you want to see another block-buster antenna? Well, here's a photograph of the array at JA1KSO in Japan (fig. 14). No details, but I see a tribander beam at the bottom, plus a six meter array. Then at the top is a 40 meter beam, plus two other arrays for 10 and 15 meters. And to top it all off, a 4-bay array for 144 MHz. That's quite an antenna farm."

"Yep", said Pendergast. "It makes me proud when I work DX with my ground plane to think of all the Big Guns that I beat out!"

"The ionosphere is a great leveller of signals", I replied as I gathered up the photographs. "The station with the big antenna has a lot going for him, but he's not always the loudest signal, nor the first one to win out in a pile-up. Operating skill still means a lot and being at the right place at the right time is very important. I've worked a lot of DX from exotic overseas locations and let me tell you it is very easy to pull an S-6 signal out of a pileup of S-9 signals. Of course, when everybody is piled up on a single frequency and the skip is good, everybody is S-9 plus and you can't understand anything. But, with the breaks, the fellows with small anten-

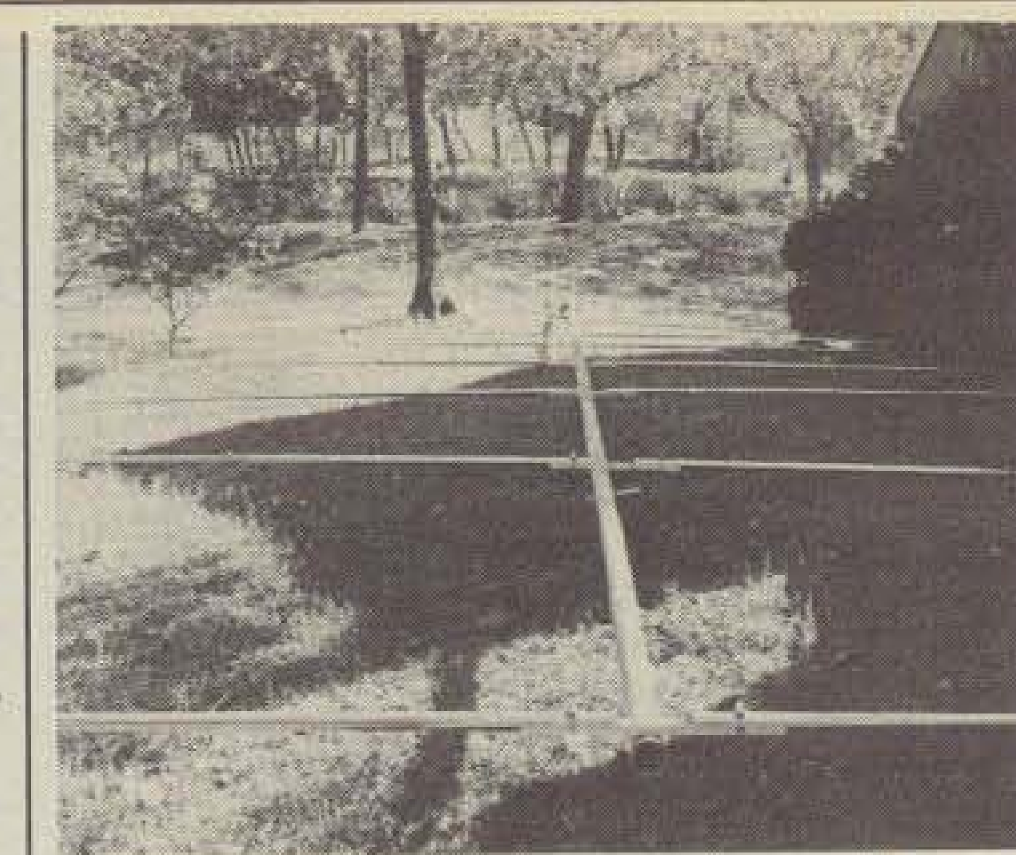


Fig. 9 - An experimental eight element Yagi on an 82 foot boom is ready to go up at K5DUT. Watch out for this one!

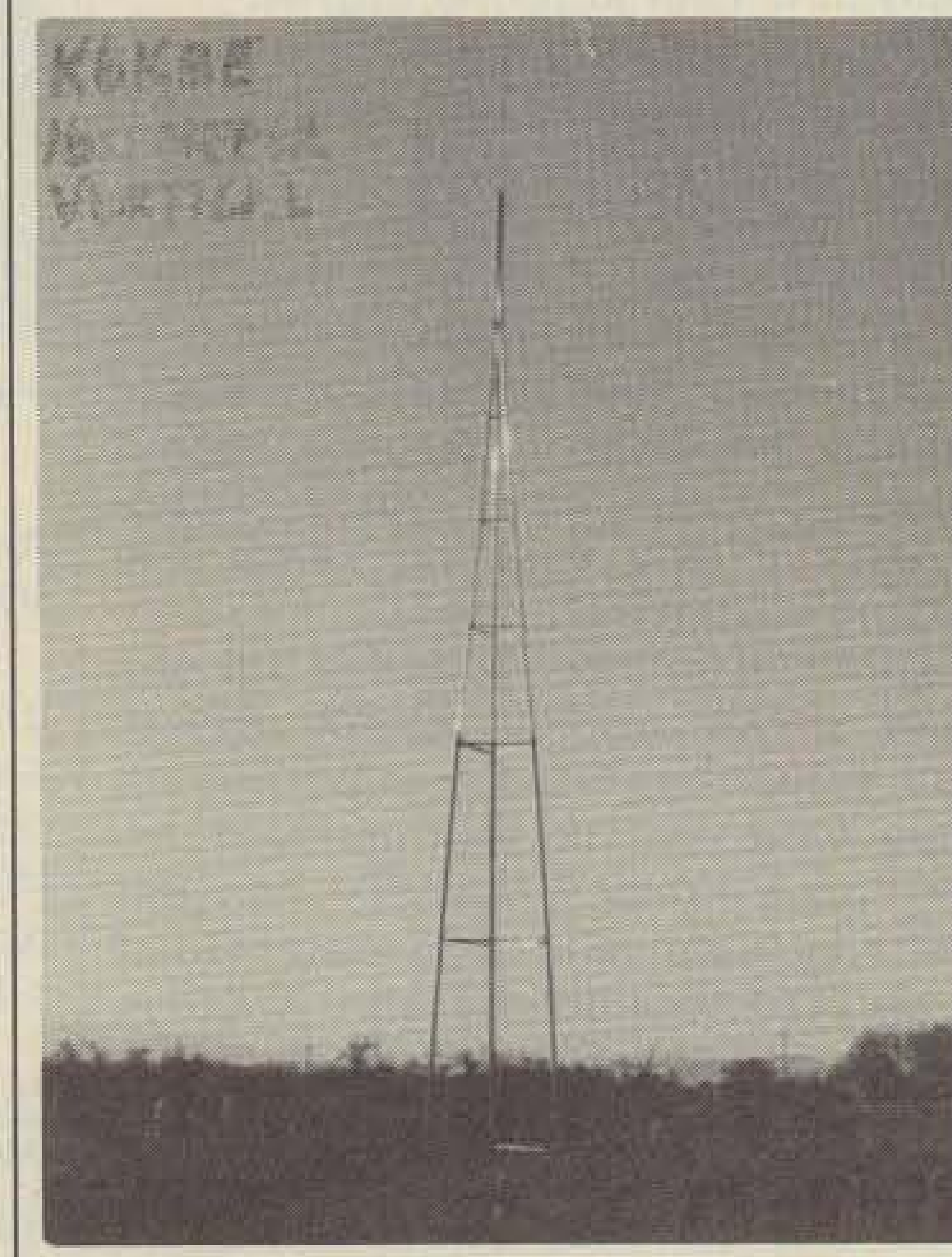


Fig. 10 - The "top band" vertical antenna at K6KBE works plenty of DX on 160 meters. Self-supporting tower can also be tuned for 80 meter operation.

Fig. 11 - A top view of the tower before erection. Note the Eiffel-tower effect of tapering.

Fig. 12 - The tower at K6KBE is insulated from ground by means of fiberglass plates which hold tower to the mounting base.

nas still work plenty of DX. You can count on that. Especially now that 10 meters is booming. Power and big antennas don't mean so much on that band."

"I agree", said my friend. He went out the front door and then called back, "I'll see you next week. I need some ideas for my next Quad antenna project. But it won't be a Monster Quad. I don't have the room for that. And don't forget that Doctor Liv has just received his Advance Class License, so he's breathing hot and heavy for a new DX antenna."

"You two fellas have your summer vacation program all worked out", I laughed. "I'll see you on the low end."

Correction: The two-band loop antenna design described in the March, 1979 antenna column was erroneously attributed to W3GNQ. This antenna is an original design of George Badger, W6TC. George furnished the information concerning two-band operation to Dick, W3GNQ. My apologies to all concerned.

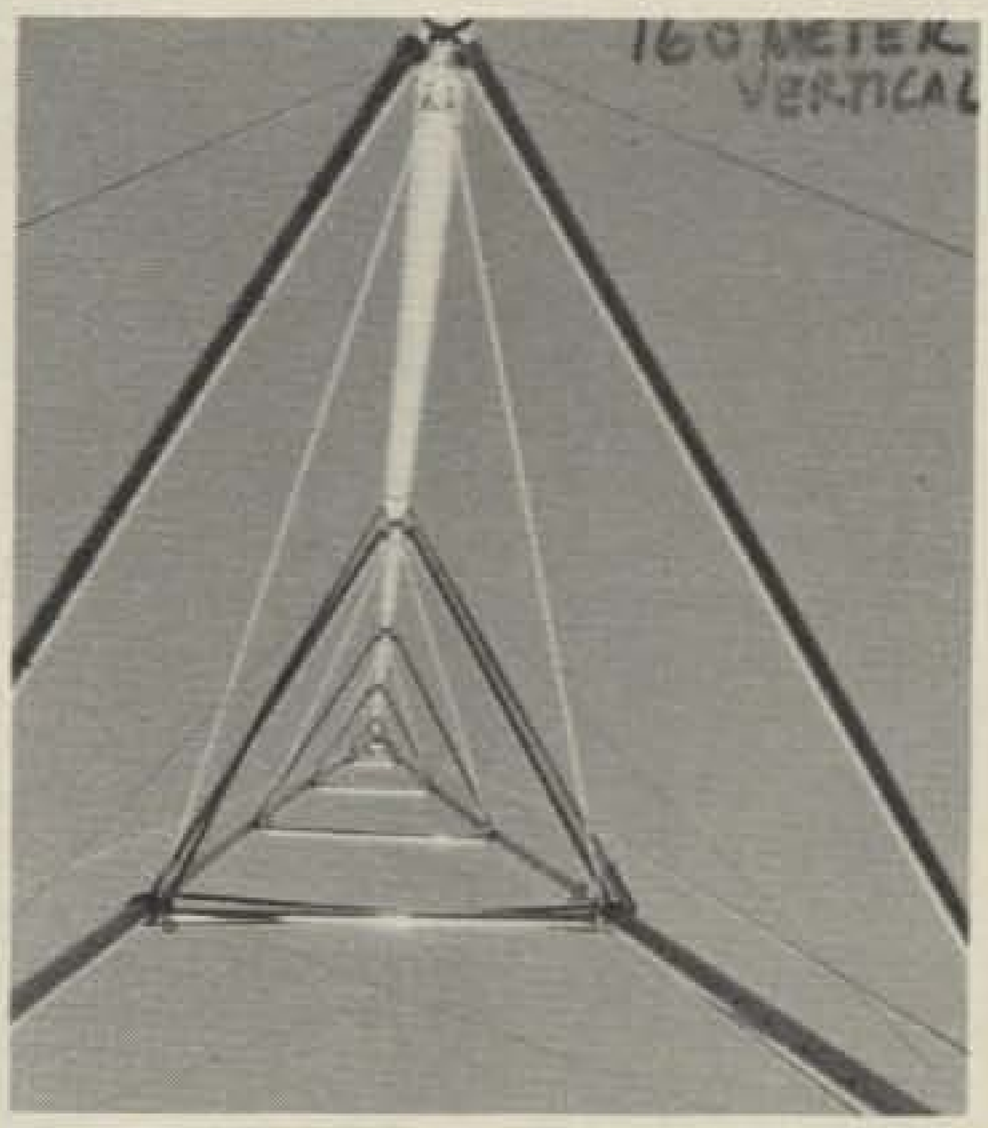


Fig. 13 - Looking up inside K6KBE's tower showing internal stressing.

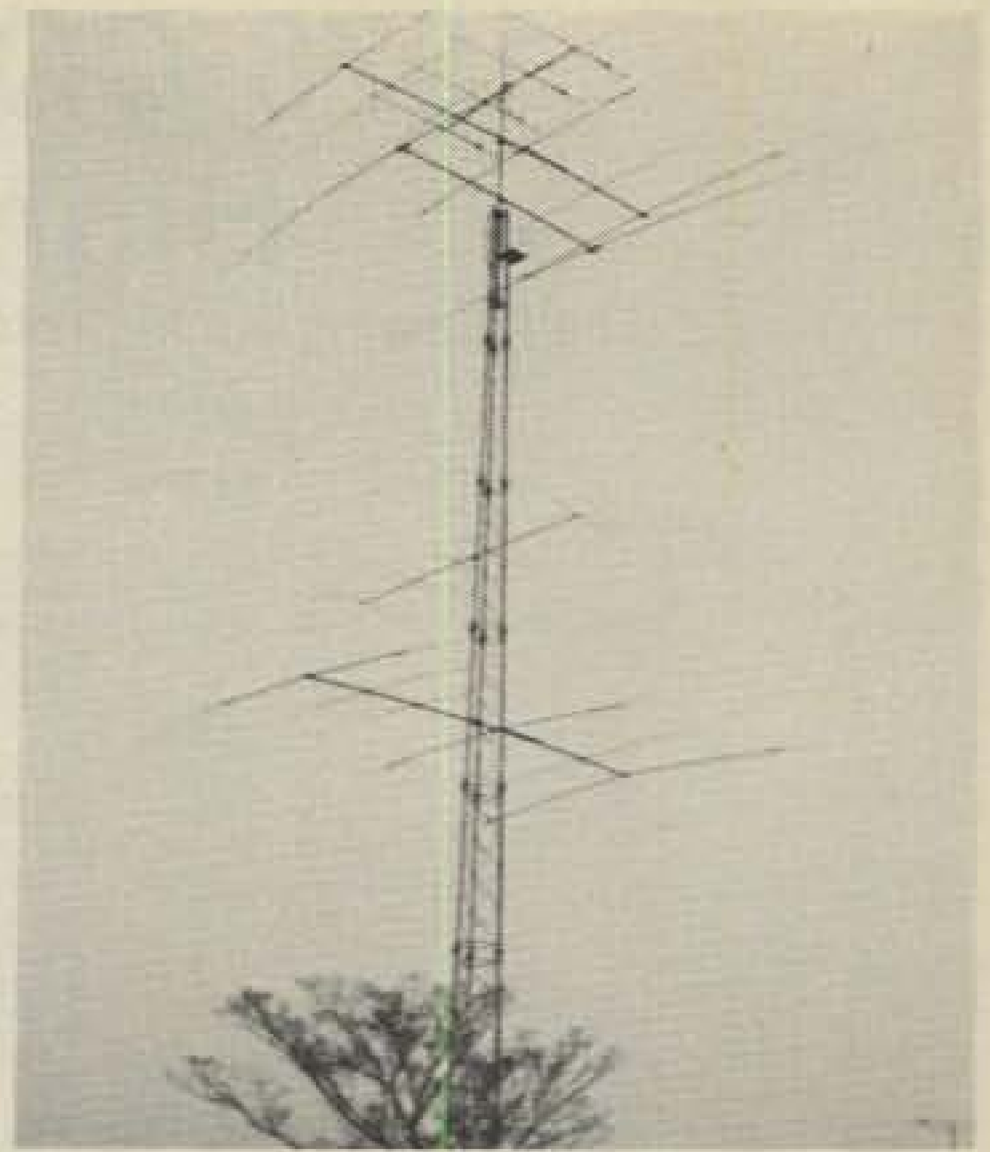


Fig. 14 - The "Christmas Tree" antenna installation at JA1KSO.

For additional information on beam antennas of all types, plus data on simple wire antennas, be sure to read "The Radio Amateur Antenna Handbook", by W6SAI and W2LX. Available from Radio Publications, Inc., Box 149, Wilton, CT 06897. Price: $6.95 plus 50¢ to cover handling and postage.

a monthly feature by

WILLIAM I. ORR, W6SAI

Antennas

Design, construction, fact, and even some fiction

I must admit that Doctor Livingston I. Presume looked unhappy. He sat across the desk from me and didn't say a word as I finished up a batch of QSL cards to go overseas. Finally, in order to get the conversation off dead-center, I said, "Well, how was your vacation trip? Do any hamming?"

Dr. Liv sighed. "Yes", he replied slowly. "But not very much. I ran into a real problem."

"Tell me about it", I suggested, sweeping the cards to one side of the table. "Let me be your shrink. Tell me all".

c/o CQ

My friend laughed. "I had a terrible time, ham radio-wise. I took my portable rig along, the transceiver, antenna tuner and a random-length wire for an antenna. I ran the wire from the living room across a yard to the next building and hooked it onto a stairway balcony. It was a nice antenna, about 40 feet high. And I laid out a bunch of radial wires for 20, 15 and 10 meters on the porch. It was a pretty good setup, but I never used it".

Doctor Liv stopped, so I asked the inevitable question.

"Why not?"

"I'll tell you! As soon as I got the transceiver loaded up properly and hit the key, all the *smoke detectors* in the building next door went off! What a racket! It scared the hell out of me and all my neighbors! Can you imagine the racket made by eight smoke detectors going off at once?"

"I can imagine", I replied.

Doctor Liv. continued. "The neighbors were mad, frightened and puzzled. And I don't blame them. I was unhappy, too. Luckily, no one jumped to the conclusion that the antenna wire had anything to do with the problem. I sneaked back into the living room while the neighbors were milling around and hit the key again, and the smoke detectors went off—bang! Just like that."

"Well, what did you end up doing about it?"

"I stayed off the air the rest of the day. A repairman came around to look at the smoke detectors, but he didn't do anything and finally went away. That night, I took down the long wire and moved it at right angles to the building. Next morning I went on the air—very timidly, I assure you—but the problem seemed over. The smoke detectors were quiet.

"But it seems a damned shame that I was caught in such a bind. I was only running about 180 watts, but I guess the strong r.f. field around the end of the wire was enough to set off the smoke detectors. It's just too bad that junk like that is allowed on the market! Why should a smoke detector be sensitive to r.f.?"

"I don't know", I replied. "I've never seen the schematic of one. But perhaps one of the readers of my *CQ* column has the answer. How do you clean up a smoke detector so that it doesn't go off when exposed to a nearby r.f. field?"

"Whoever has the answer to that question can certainly do a public service by helping fellows like myself that have run afoul of the beasties". Liv. frowned, and then turned to a more happy subject: antennas.

"Look at this letter I received from Charley, WB4PVT (fig. 1). He wanted a sloper antenna that would cover the whole 80 meter band. So he tried the idea of using two parallel-connected slopers, one cut for 3.7 MHz. and the other cut for 4.0 MHz. The wire ends were separated by about 30 feet. The sloper was mounted to the side of his tower at about the 50 foot level. As you know, the sloper is a quarter-wave wire that uses the tower itself

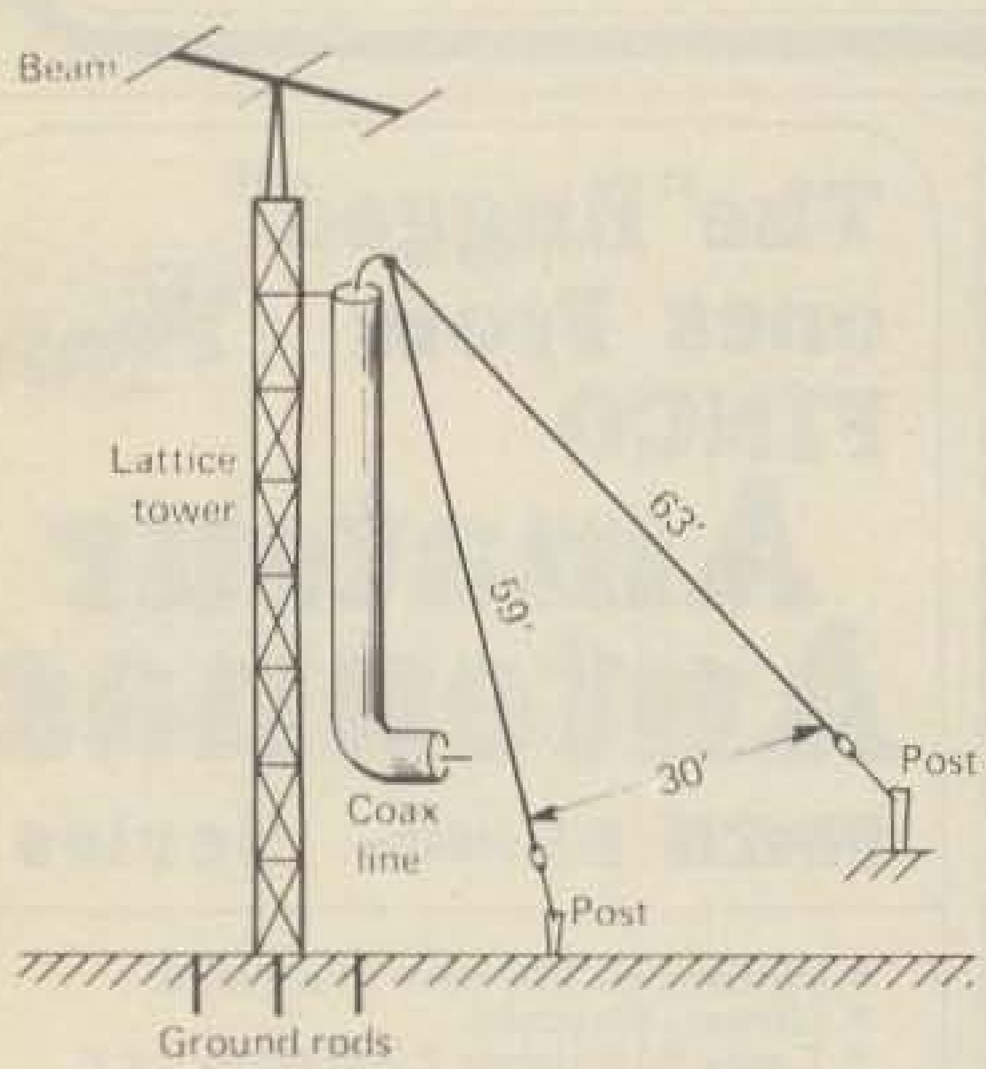


Fig. 1-The wideband 80 meter sloper antenna of WB4PVT. Charles uses two sloper wires connected in parallel at the feed point. One wire is cut for 3650 KHz. and the other one for 3975 KHz. Separation of the wire ends near ground level is about 30 feet. Resonance and s.w.r. curve can be varied by moving the ends farther apart, or changing height above ground. End height of about 10 feet is suggested. Parallel connected wires are fed from center conductor of RG-8/U feedline and outer shield is grounded to the tower. A No. 10 ground wire runs from ground rods at base of tower up to the point on the tower at which the shield is attached.

Fig. 2 — The dual-polarity Avanti 10 meter Quad at WD9ABG. This novel antenna provides either horizontal or vertical polarization at the flick of a switch. Matching sections are folded into a loop at the center of the director. Switchable polarization is very useful for DX work says Marty.

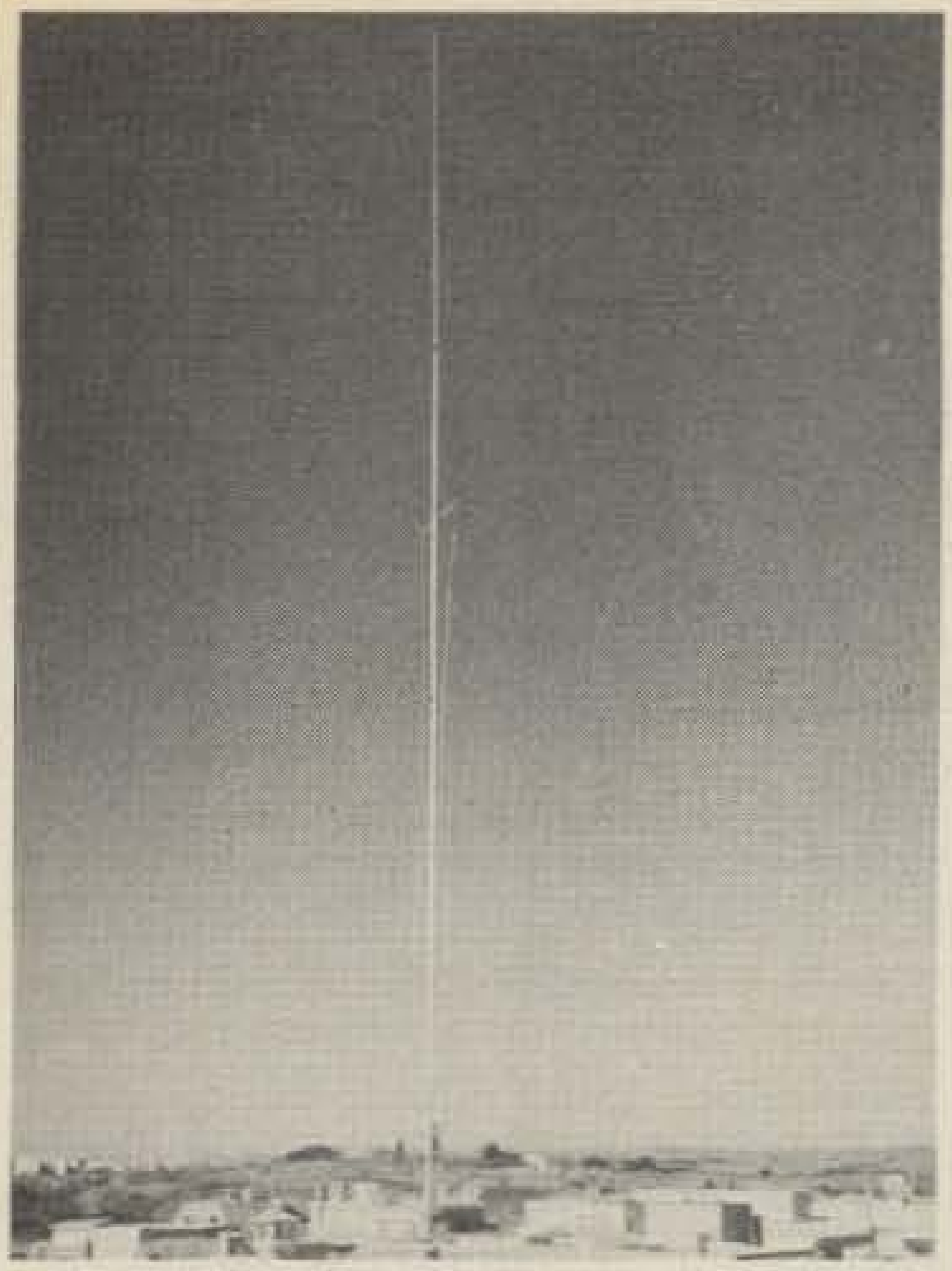


Fig. 3-The "all-band" vertical antenna of I0ZV in Rome, Italy. The antenna consists of a 33'10" whip with auxiliary vertical antenna wires connected in parallel at the base. Radial wires are run on the roof of the building.

as a counterpoise, or ground system. WB4PVT ran a #10 wire down the tower to ground rods at the base. The wire was grounded both to the tower and to the braid of the coax cable at the top. The center conductor was connected to the two antenna wires. Not a bad idea for a wideband 80 meter antenna".

"Yes", I agreed. "I've never seen a wideband sloper antenna before. Nice going, Charlie."

I handed Doctor Liv. a photo (fig. 2). "This will be of interest to a 10 meter DX bug, such as yourself. This was sent to me by Marty, WD9ABG. This is the new Avanti PDL 5X10 dual-polarity Quad, Model ARD-122. Avanti is getting into the ham antenna field, after many years dominating the CB market.This is one of their first ham designs.

"Basically, it is a two element Quad whose polarization can be controlled from the operator's position. Your choice of either horizontal or vertical polarization at the flick of a switch! The antenna has two gamma matches, two feedlines and a coaxial switch. Marty has his PDL array cut for 29.6 MHz. and uses it on 10 meter FM. He finds that polarity switching is very effective in reducing phase distortion that shows up on FM skip signals. Some signals that are completely unreadable due to phase distortion are completely readable when antenna polarization is changed. And, of course, vertical polarization comes in handy when working local mobile stations".

"Which is best for DX work, horizontal or vertical polarization?", queried Doctor Liv.

"Ah, that's the question", I replied. "Theory has it that ionospheric-reflected high frequency waves lose their original polarization and that the reflected wave is randomly polarized. That may be true. It certainly is interesting to switch back and forth from horizontal to vertical polarization on a DX signal and watch the S-meter. On some very long skip signals, the vertical polarization produces a good signal which completely drops out when the antenna is switched to horizontal polarization. In any event, it is very convenient to able to switch polarization at will. It can really pay off on 10 meters, regardless of the mode of transmission".

I reached into the desk drawer and produced a letter which I tossed to Doctor Liv.

"Look at this "all-band" vertical antenna that Francesco, I0ZV is using on the Via Flamina in Rome, the Eternal City. I'm sure that you've heard his robust signal on the bands. It is a very simple and effective installation (fig. 3). Francesco has a 33'10" aluminum whip antenna which is resonant at about 7080 kHz. There are two 33 foot radial wires running across the roof of the building to form a ground return. The whip element diameter at the base is 1-5/8", tapering to 7/16" at the top. The antenna also operates as-is on the third harmonic at 21 MHz".

"That takes care of two bands", observed Doctor Liv as he studied

Fig. 4-The base of the I0ZV antenna showing the radial wires, antenna support and 80 meter loading coil. Note the 20 and 10 meter vertical wires running parallel to the aluminum tube.

the photographs (fig. 4 and 5).

"The antenna is base loaded for 80 meter operation by a coil made of aluminum fence wire (1/8-inch diameter). The coil has 17 turns, 2-3/4" diameter and is about 3-1/2" long. Resonance is at 3.7 MHz. The number of turns can be adjusted to move the resonance point about in the band. One 135 foot radial is used for 80 meters. It is run around the roof in a haphazard fashion.

"An aluminum cross-bar is clamped to the antenna at the 20 foot level. This supports the 20 and 10 meter verticals, which are 16'6" and 8'2" long respectively. The aluminum

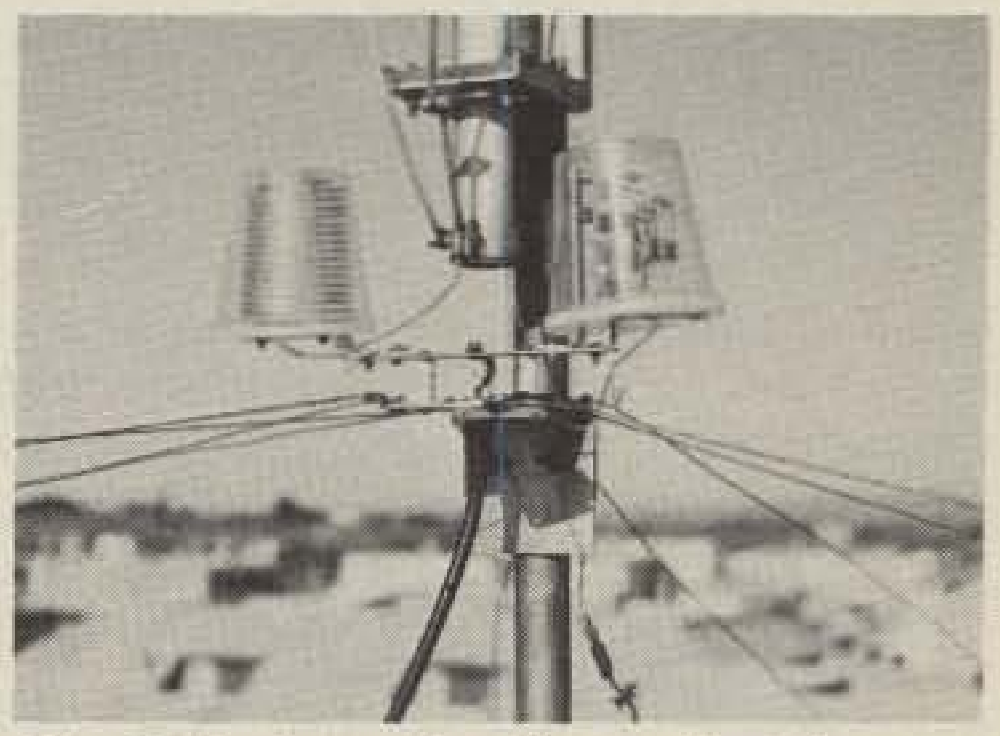


Fig. 5-The base loading coil of the vertical antenna is placed in a plastic cup as is the relay which places the coil in the circuit. Francesco reports good DX with this antenna on all high frequency bands: 80 through 10 meters.

wires are fastened to the cross-bar with nylon rope. The bar is two feet long so that the wires are spaced away from the vertical aluminum element. The wires and the tubing are all connected together at the base of the antenna. Two radials for each band are added at the base; their lengths are 16'6", 11'2" and 8'4" respectively for 20, 15 and 10 meters.

"The vertical is guyed at the 20 foot level by nylon ropes to counteract the winter winds and the base is held to a supporting structure by an insulating plate.

"Francesco notes the s.w.r. is less than 2.5-to-1 from 3.6 to 3.8 MHz., with a minimum of 1.2-to-1 at resonance. S.w.r. minimum on 40 meters is 1.4-to-1; 20 meters, 1.2-to-1; 1.9-to-1 on 15 meters and 1.4-to-1 on 10 meters".

"Very good!", exclaimed Doctor Liv. He looked at the letter and photographs. "I see Francesco has had the antenna up and working with no problems since 1971. It must be a good design to stay up all that time!"

"Many DXers use a vertical antenna of this type", I replied. It is about the only answer if you are space-limited. If you have the space to run the radials out below the antenna, your problems are solved".

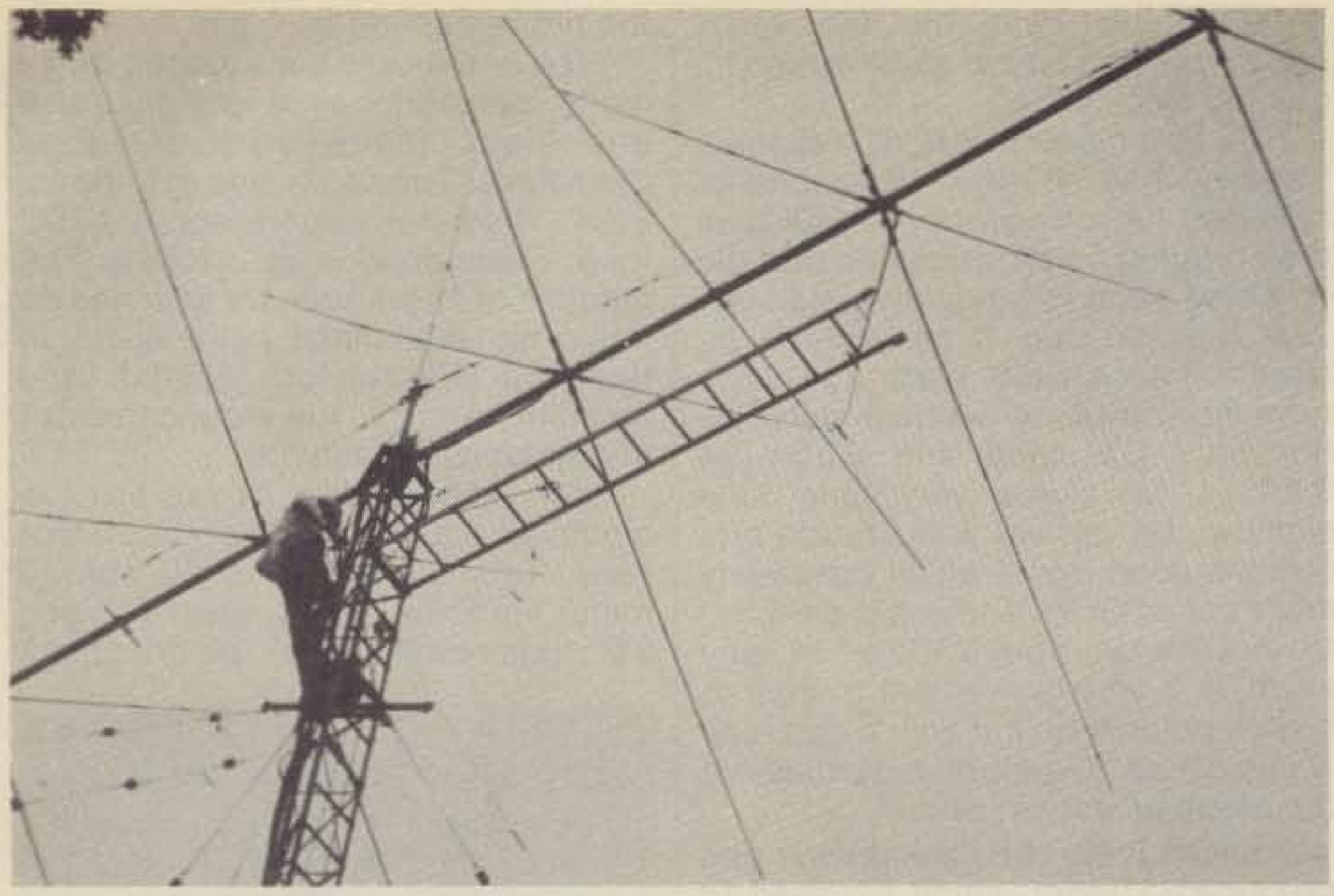


Fig. 6 — Lew, K4VX, installs temporary outrigger at top of his 100 foot tower so that he can repair his Monster Quad without having to lower it to the ground. Aluminum ladder is bolted to the tower and free end is guyed back to the top of the tower. Outrigger was tested at 3 foot level before it was installed at 96 foot level!

"Let me see the letter you got from Lew, K4VX", urged Doctor Liv. "I understand he has a nifty way of repairing a Monster Quad without taking it down from the tower".

"That's right", I replied." Lew writes that a lot of information about Monster Quads has appeared in this column but not much advice on how to repair the broken elements that are beyond reach from the tower".

"It's a real hassle to take down a four element Quad", agreed Doctor Liv. "How did Lew handle the problem?"

"Lew says last year his 10 meter driven element opened up at the feedpoint. The Monster Quad was on top of a 100 foot tower and he hated to think of hauling the antenna down for repairs.

"Lew decided to repair the element in place. He disassembled one section of an aluminum extension ladder and mounted the bottom of it to a section of angle iron which was drilled to bolt in place of one of the tower steps. The ladder projected out from the tower and the free end was guyed back to the top of the tower by means of 3/16-inch diameter aircraft cable.

"Before Lew put this outrigger atop his tower he mounted it about 3 feet clear of the ground and worked with it until he was satisfied it was safe. He then remounted it at the 96 foot level on the tower (fig. 6) and slowly crawled out on the ladder with a bag of tools to repair the feed point. His buddy, K4EBY, took these shots with a telephoto lens".

"Wow", said the good Doctor as he studied the photos. That takes plenty of nerve to crawl out on that ladder 96 feet up in the air (fig. 7). I get a nosebleed even thinking about it!"

"I agree", I replied, "But I'm not as young as I used to be". "Lew said he put the Quad up originally with a messenger cable strung from the top of the tower to another tower about 150 feet away. A pulley which could ride as a trolley along the messenger cable held a 3-pulley block. A rope at the pulley block went to the Quad tower. The Quad was assembled on the ground between the towers and a 2-pulley block was secured to the Quad boom at the center of gravity. Two hams hauled the six element Quad up into the clear between the towers and then walked slowly towards the Quad tower, pulling the Quad along with them. Once the Quad boom could be reached by a small winch cable, W3GRF and K4VX winched the Quad in place and set the bolts. The guys on the ground were K7ZZ, N4SW, K6BRB and some s.w.l.'s.

"One other item of interest: Lew used 8 foot spacing between Quad elements which worked fine on all bands, however on 10 meters he mounted a 15'6" long Yagi director element between the driven loops and the first set of Quad directors. This improved the 10 meter pattern and also reduced the feed point impedance on 10 meters from 120 ohms to about 55 ohms.

"Lew says he is a contest operator primarily and that this antenna takes a back seat to no one on the East Coast, including checks with W3AU and his element, 10 meter Yagi.

"Finally, Lew says that an ice-covered Quad makes a very good rotary dummy load in the winter months, and the last few storms proved that!"

"Amazing", said Doctor Liv as he studied the photographs. "I would hate to tangle with K4VX. I wonder what all the Monster Quad enthusiasts in Cow Town (Fort Worth) think of this East Coast competition?"

"They must be aware of K4VX. I guess they are just too modest to comment", I replied.

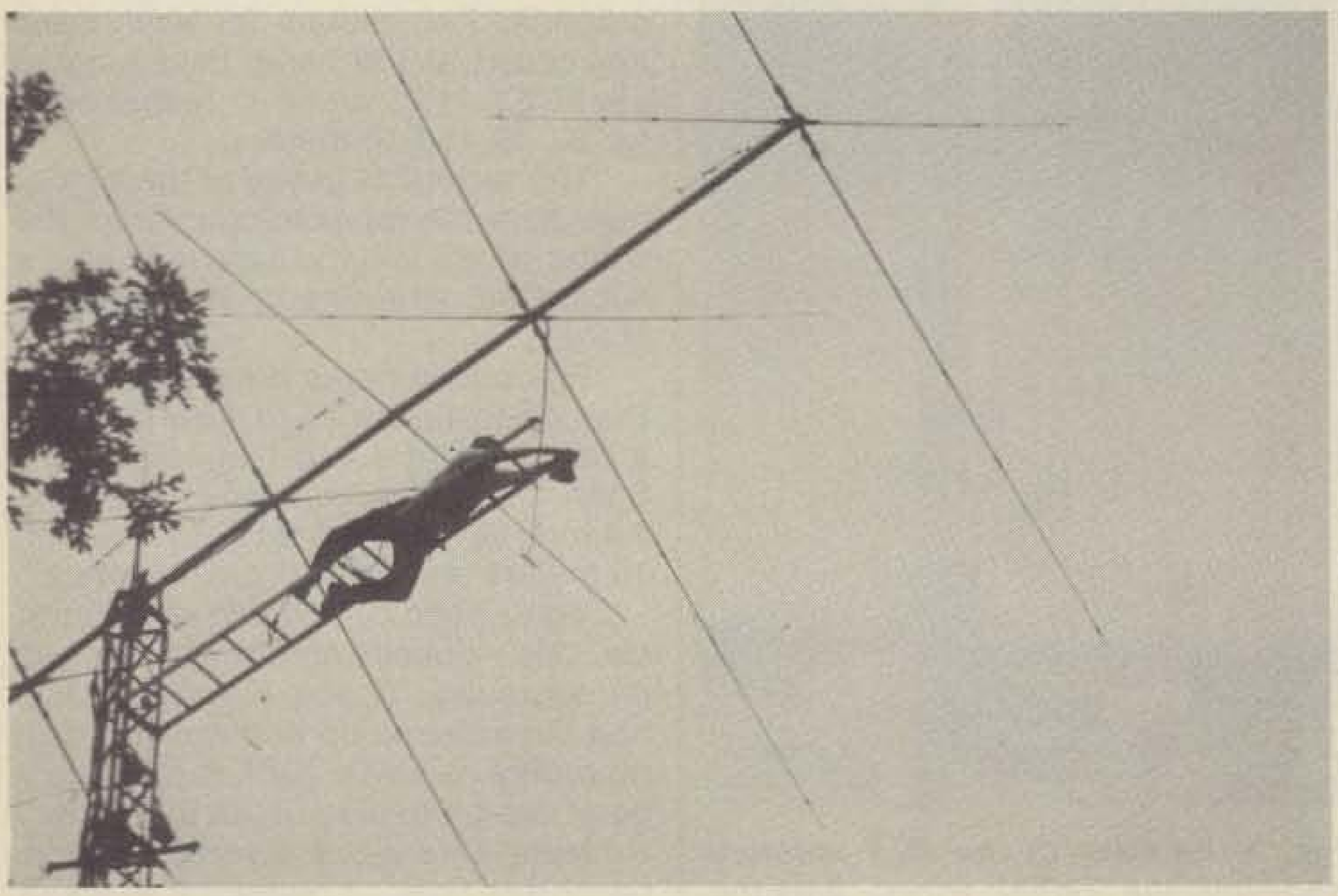


Fig. 7 — K4VX repairing his Monster Quad! Note the extra 10 meter Yagi director element (behing Lew). This improves coupling to the first 10 meter director, providing better front-to-back ratio and lowering impediance of driven element to about 55 ohms on 10 meters.

a monthly feature by

WILLIAM I. ORR, W6SAI

Antennas

Design, construction, fact, and even some fiction

"Who's your friend?", I asked as Pendergast swept into the ham shack with a large bumpkin in tow.

Pendergast sat down in my favorite operating chair and motioned towards his companion. "I want you to meet Johnathan Cadaver. He's a Country-Western song writer and studying for his Novice ticket".

Johnathan engulfed my outstretched hand in a bear-like grasp and said that he was pleased to meet me. He didn't sound like a song writer at all.

"Well, what songs have you written?", I asked in a cheery tone.

Johnathan sighed and said, "Have you ever heard *I'd Rather Have A Bottle In Front Of Me Than A Frontal Lobotomy?"*

"No, I don't think I have", I replied.

"How about *Take Back Your Golden Garter, Mother, My Calf Is Turning Green?"*

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Fig. 1-The antenna farm at DXer W3GRF. A four element 40 meter beam with eight interlaced 10 meter elements on a 70-foot boom (photo by K4VX).

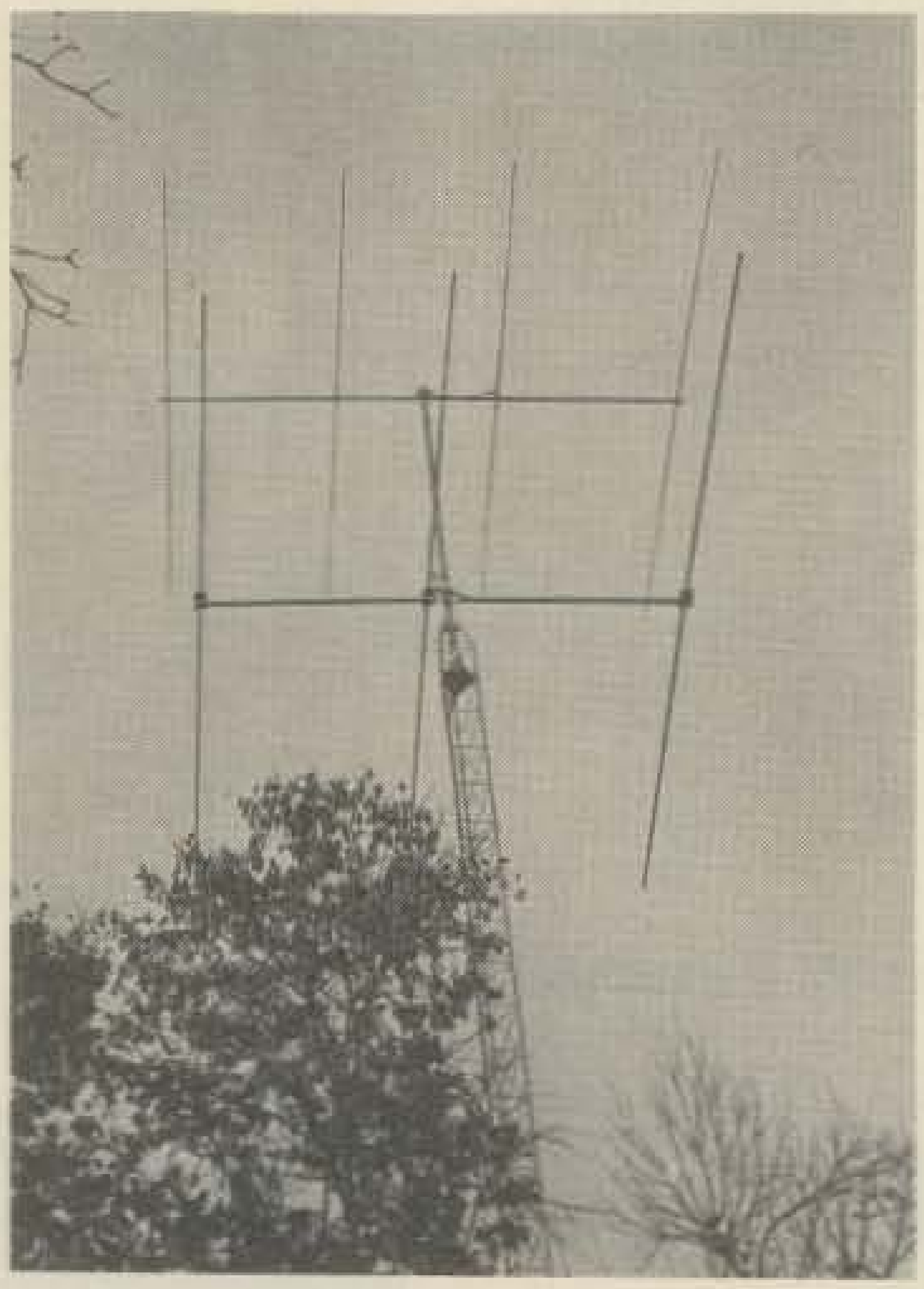

Fig. 2-The stacked beams at WD9GMA for 10 and 15 meter operation feature the new Gamma match design of KA9ACN.

I shook my head.

Pendergast sighed deeply and said, "Johnathan, I think you had better concentrate on your Novice license for a while and forget about Country-Western music".

"I guess you're right", replied Johnathan. "I should be able to take the exam in a few weeks".

"One of the fun things about ham radio is the hobby of antennas", said Pendergast. "You'll have a lot of fun, Johnathan, working on antennas. Sometimes that's more fun than talking on the air".

"Pendergast is right, as usual", I remarked. "As an example of what's happening these days, here's a picture of the antenna farm at W3GRF (fig. 1). Lenny has a four element 40 meter beam with eight interlaced 10 meter elements on a 70-foot boom. This picture was taken by K4VX. Isn't that a beautiful antenna?"

Johnathan studied the photograph. "I'd have to write a lot of songs to pay for that", he announced.

"A lot of fellows have less expensive installations than that One", I said. "Look at the antennas at WD9GMA and KA9ACN and KA9ACO (figs. 2 and 3). These are homemade stacked 15 and 10 meter beams. Larry, KA9ACN, is working on a new design for the Gamma and Omega matches and hopes to have information available on an improved version very soon".

"Fine", remarked Pendergast. "I've had nothing but trouble with the Gamma match on my beam. Changes in temperature, humidity and barometric pressure play havoc as far as keeping the container that houses the capacitor sealed. And it's harder and more expensive each year to find a suitable transmitting capacitor for the matching system".

"Larry hopes to have these problems solved soon. As soon as I receive word from him, I'll let you know", I said.

"Anything else in the old mail bag?", asked my friend.

"Well, I received a letter from Matt, WB6HSG, with a beautiful photograph of his antenna (fig. 4). Matt wanted me to know that all of the Monster Quads are not located in Fort Worth or Dallas.

"Matt's antenna is mounted on a 48 foot boom and consists of six elements on 20 meters, 7 elements on 15 meters and 9 elements on 10 meters.

The Monster Quad is mounted on a *Tri-Ex* "Sky Needle" TM-37OHDC at a height of 96 feet. The Quad loops are constructed of No. 14, nineteen strand, teflon covered wire (white). The spreader arms and spiders are by *Cubex*. And Matt uses separate coaxial lines to each driven element.

"The antenna was tuned and dipped to frequency at a height of 52 feet with the aid of a crane and a 70 foot ladder boom. Matt says he can't measure the gain, but it appears very good, and the front-to-back ratio is better than 35 dB on all bands".

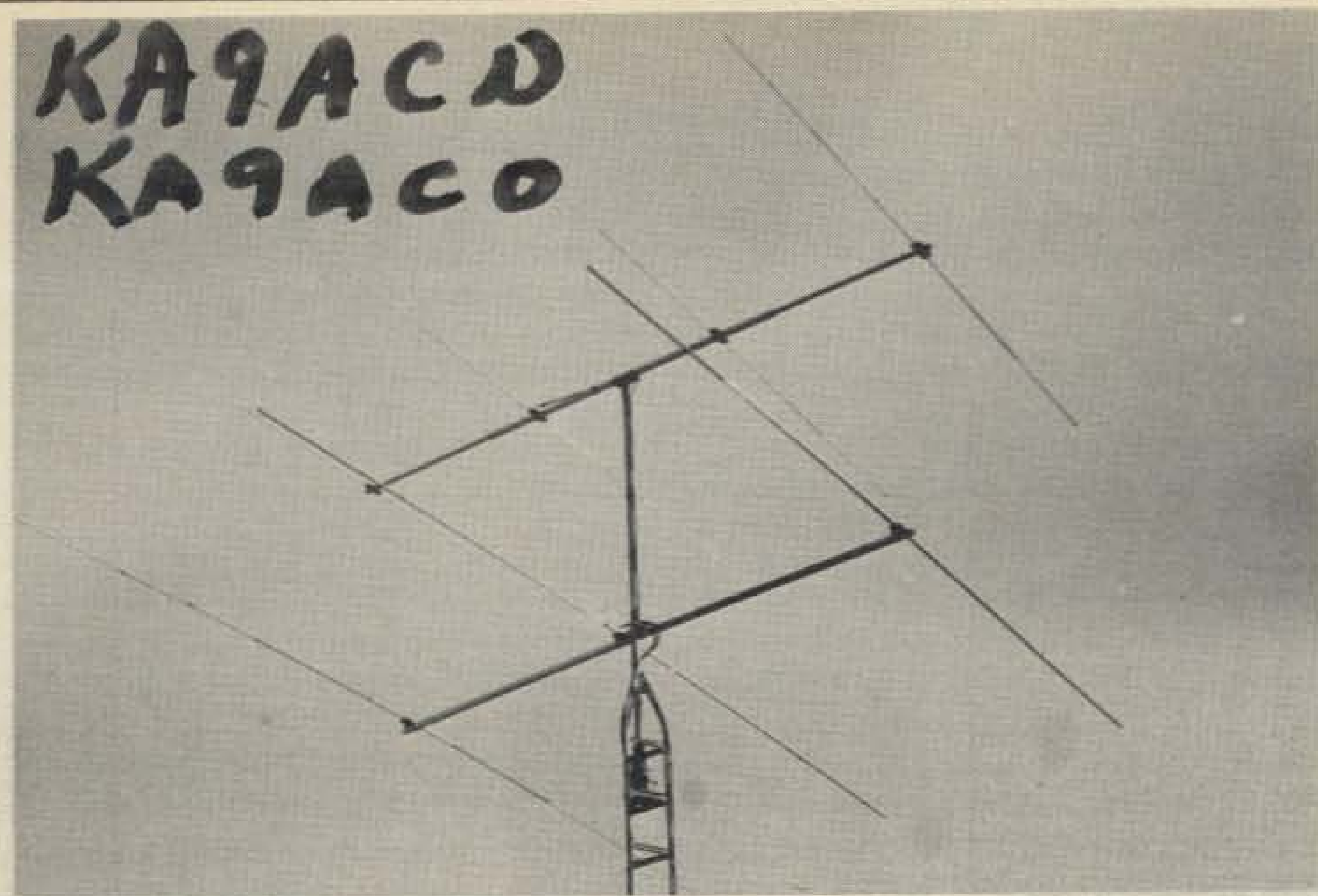

Fig. 3-Another stacked 10 and 15 meter combo at KA9ACD and KA9ACO. Three elements on 15 and 4 elements on 10 meters. A neat installation.

"Those are pretty impressive figures", intoned Pendergast as he and Johnathan studied the illustrations.

"Matt goes on to say that he's going to make some on-the-air comparisons soon. He's installing another tower about 150 feet away from this one and will make comparison tests using the Quad against a long-boom Yagi and a six element *KLM* array. He's also going to check

Fig. 4-How's this for a first-class Monster Quad? The impressive multiband job at WB6HSG. Matt has six elements on 20 meters, seven elements on 15 meters and 9 elements on 10 meters, all on a 48 foot boom. Array is at 96 feet on a Tri-Ex "Sky Needle".

out some smaller three and four element Yagi beams as time permits".

"Sounds great", said Pendergast. "I'm looking forward to hearing all about his experiments".

"Here's some more information that may be of interest to you". I handed Pendergast a letter. "This is from John, VE2CV. He has the great advantage of being able to run tests on an antenna range at the Canadian Department of Communications Research Center at Ottawa, Ontario. John modeled an 80 meter sloper antenna at 200 MHz. and ran tests to determine the radiation pattern of this interesting antenna. A sloper, as you know, is merely a quarter-wave antenna, coaxial fed, the uses the supporting tower as a ground plane.

"John says that the sloper radiated essentially like a vertical ground plane antenna with an essentially omnidirectional pattern (fig. 5). A slight directivity exists in the direction of the wire".

"That sounds reasonable", said Pendergast. "It is too much to expect any great degree of directivity out of such a simple antenna".

"In closing, John says that the best antenna he has run on the range is a full-wave Delta loop, apex up, and fed at one corner. This provides a vertically polarized signal with a surprising gain of about 6 dB over a dipole!

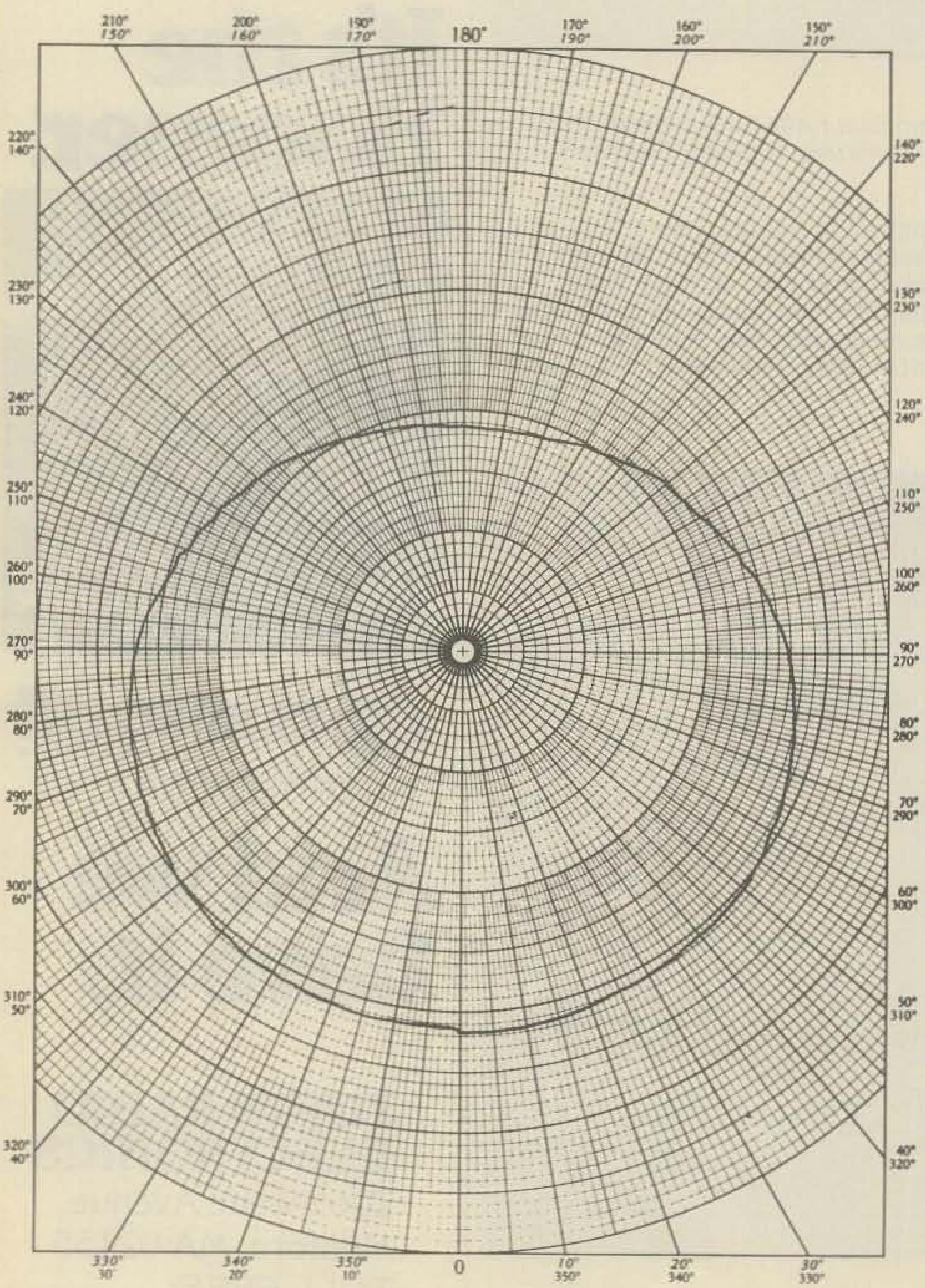

Fig. 5-Directivity pattern of sloper antenna modelled at 200 MHz by VE2CV. Sloper pattern is essentially the same as a vertical antenna, with a slight directivity exhibited away from the tower.

He measured the input impedance at about 150 ohms and used to 4-to-1 balun to match a 50 ohm coaxial transmission line. He says that one basic problem is that ground cannot be properly modelled as a finitely conducting earth".

Pendergast smiled. "Just tell John that earth can be approximated at S-band (2-4 Gc) by coating the ground plane with peanut butter!"

"That's a handy thing to know", I replied.

Johnathan, who had been listening intently to the discussion finally spoke up. "Well, I'm not a ham yet. And I don't understand a lot of this conversation. Aren't there some simple rules about dipoles and ground plane antennas that I can understand and that will help me when I get on the air?"

"Yes", I replied. *Radio Communication*, the monthly magazine of the *Radio Society of Great Britain*, reprinted an article by ZL2AKW of New Zealand, published originally in "Break-In". These rules summarize the state of things very nicely and dispel a lot of "antenna lore" that is floating around. Here they are:

1- A dipole cut for the middle of the 80 meter band and fed with an 50 ohm line via an antenna tuner will work over the whole 80 meter band.

2- The same antenna, fed with 300 ohm ribbon line, or open-wire line, will work on any band from 160 meters through 10 meters.

3- Unless higher than 150 feet, it hardly matters on 80 meters in which direction the dipole points: more significant will be the obstructions, trees, etc. which absorb some of the power.

4- A long antenna provides more microvolts to the receiver than a short one but a transmitting antenna radiates all the power fed to it (minus IR loss).

5- Antennas, and the equipment connected to them, can confidently be expected to provide better and better results on the high frequency bands as the sunspot cycle goes up and up.

6- The result of doubling your r.f. output will be virtually unnoticeable, but halving input power may well be noticeable since output efficiency may be affected.

7- A poor antenna is always a poor antenna; but when conditions are good it will work.

8- There are no magic formulas or magic boxes that are able to improve the performance of a poor antenna, but it is easy to reduce dramatically the efficiency of a good antenna.

9- A bought antenna is not a better antenna than a home-made one, but merely a more expensive antenna; a better investment is a good book on antennas.

Johnathan smiled. "It sounds as if there is no easy road to a loud signal".

"That's right", I admitted. "But you can still work wonders with an inexpensive dipole antenna or a ground plane. The whole situation is relative. A good operator with a simple antenna can work plenty of DX until he is outclassed by a good operator with a big antenna. One of the toughest times for a QRP station with a simple antenna to work DX is in a DX contest. Too much competition from the big signals. On the other hand, an excellent contest operator can overcome the handicap of a simple antenna and still compete DX-wise. Unfortunately, there aren't many of us that fall in this exalted class".

I tossed Pendergast a clipping from the "Financial Times of London". "Read this", I said. "Allan, VP9AD, sent it to me. It concerns experiments run at the Royal Military College in England. It was found that a large reduction in antenna length could be achieved by placing a ferrite coating on the wire. In the tests, small ferrite beads were strung on the wire. The experiments covered the frequency range of 5 MHz. to 100 MHz. The lower frequency limit was limited only by the bulk and weight of the beads".

"You mean I can string ferrite beads on a wire—a dipole— and reduce the physical length?", demanded my friend.

"That's what it looks like to me", I replied. "This may be the way to make a physically small Yagi beam antenna".

"Maybe that'll be the next breakthrough in mini-antennas", said Pendergast hopefully. "I hope to hear more about ferrite loaded wires. And I also hope you can tell me what this is all about". He handed me a small drawing torn from a magazine.

"This is from a recent issue of *CQ-Ham Radio*, published in Japan. It looks like the driven element of a Quad antenna (fig. 6). Too bad I can't read Japanese! But look at that interesting feed system! Is it an attempt to broadband a Quad loop? The dimensions are in meters, so this looks like it is a 20 meter loop."

I studied the drawing. "This seems like a first cousin to the so-called 80 meter coaxial dipole which was supposed to provide broadband coverage of the entire 80 meter band".

"But it didn't, did it?", interrupted Pendergast. "I remember that Walt Maxwell, W2DU, pretty well shot that antenna down in flames in one of his articles".

"I remember that", I said. "Perhaps this loop feed system doesn't work any better. But hope springs eternal. I would like to try it out".

It looked as if Pendergast and Johnathan were getting ready to depart, so as a final remark, I said, "Before you go, you might be interested in the simple 80 meter vertical antenna at WD9AXF. Jack wanted a quick vertical for DX work. He hung 50 feet of RG-58/U coax in a pine tree and used the outer shield as the radiator. At the bottom of the antenna he inserted a surplus coil (2-½ inches in diameter and 11 turns per inch, about 8 inches long) in series with the coaxial line to the station. He laid out 32 radials from the base of the tree, each radial about 66 feet long. Then he adjusted the number of turns in the series-connected inductor and could drop the SWR to less than 1.3-to-1 at any point in the 80 meter band.

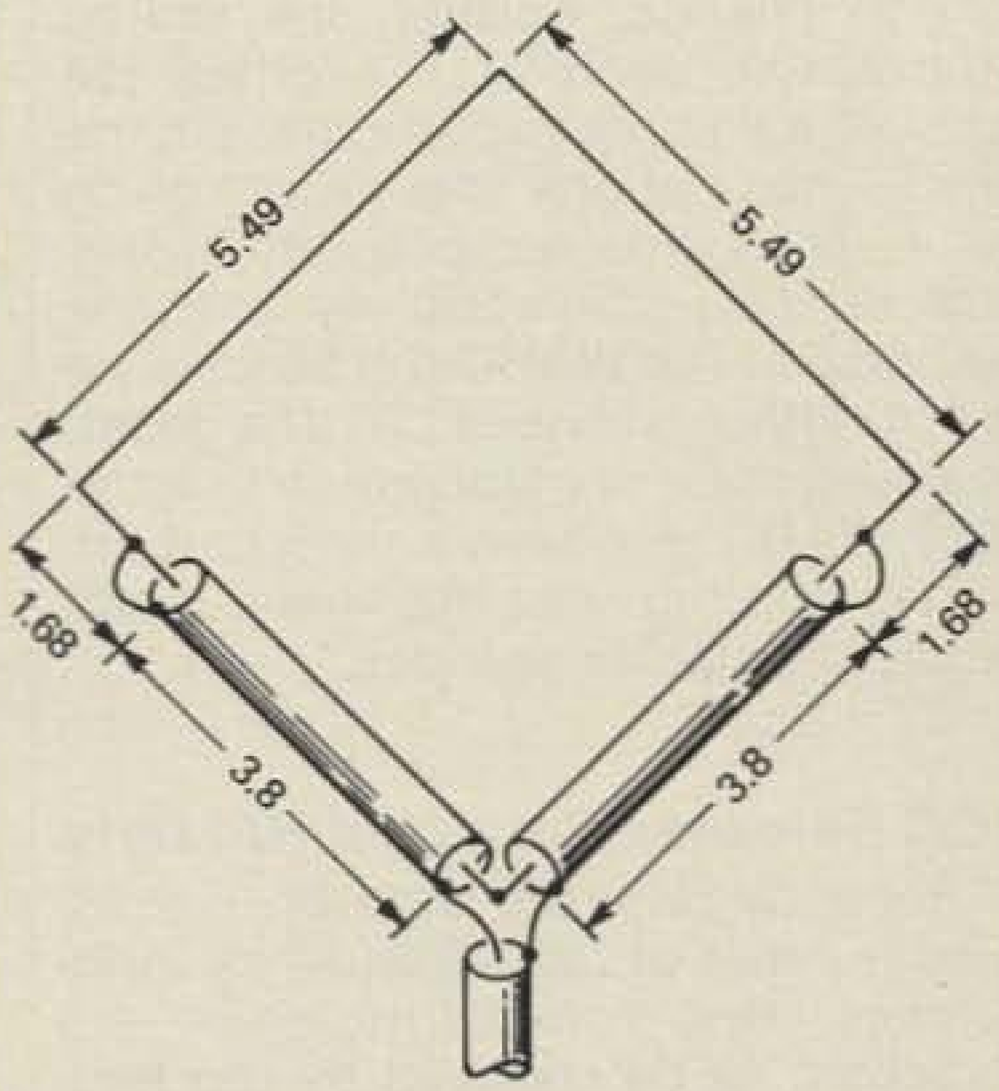

Fig. 6 — The interesting Quad loop feed system featured in the Japanese magazine CQ-ham radio. It looks like a version of the 80 meter coaxial dipole design. Dimensions are in meters.

"The RG-58/U coax he used for the vertical antenna was wrapped around the trunk of the tree as a support. And the whole thing only took a few hours to build up. Jack says that compared to his inverted-V the vertical antenna is usually weaker out to about 1200 miles but beyond that it is the better of the two.

"So there you are. A simple vertical antenna that uses a tree for support". *Note* - More antenna information? Read Bill Orr's antenna handbooks: "Simple, Low-cost Wire Antennas" ($4.95) and "All About Cubical Quad Antennas" ($4.75). Available from Radio Publications, Inc., Box 149, Wilton, CT 06897. Add 50¢ per book for postage and handling.

a monthly feature by

WILLIAM I. ORR, W6SAI

Antennas

Design, construction, fact, and even some fiction

"**B**efore any antenna talk, why don't you bring me up to date on the activities of all my friends?", I asked.

Doctor Livingston I. Presume relaxed in his chair, dropping a magazine on the operating desk and thought for a moment.

"Well, Johnathan Cadaver is still waiting for his Novice license. He took the exam a few weeks ago. And Pendergast has jilted Bella Amtrak and is now going with Gloria Goosby.

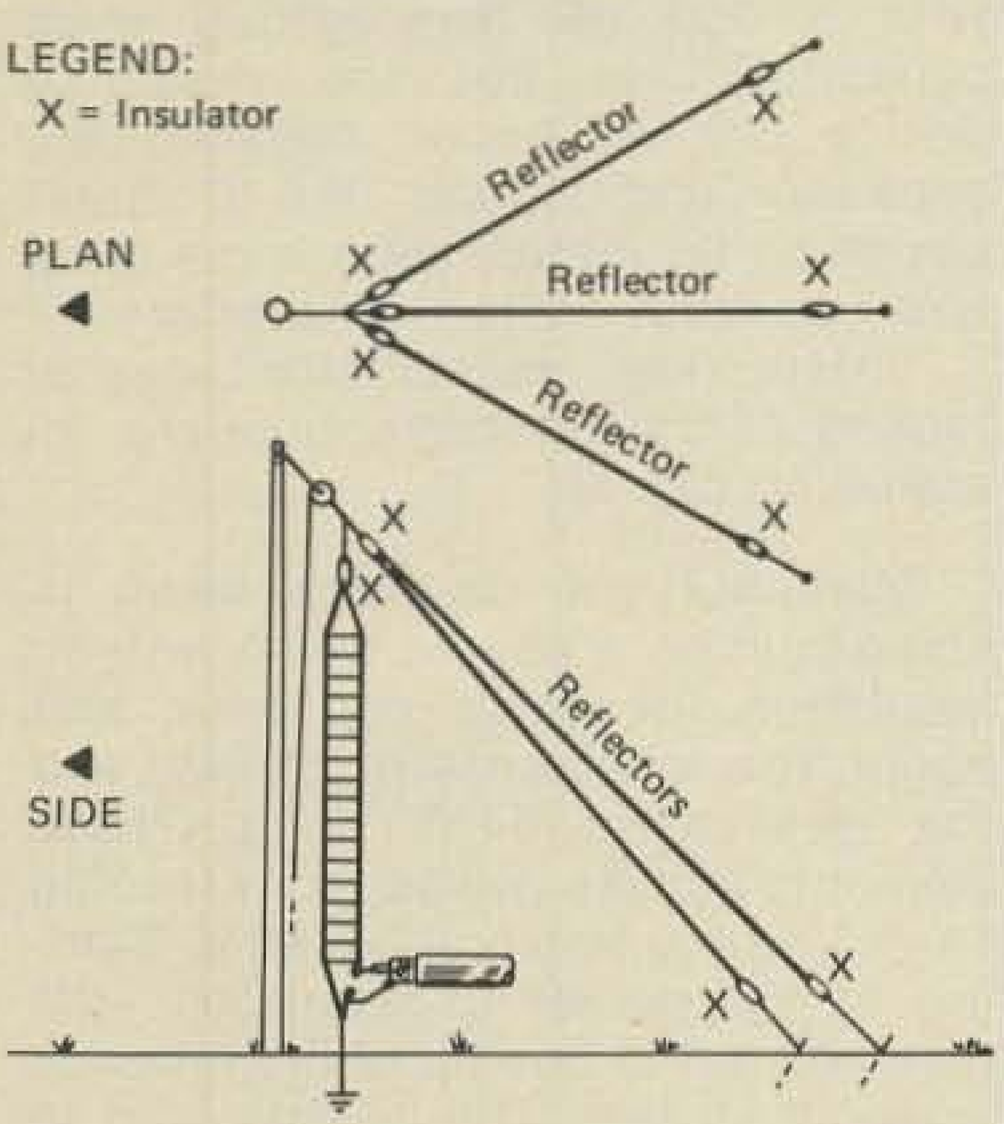

Fig. 1 - The 40 meter vertical beam of G3HCT. Three reflectors are placed behind a quarter-wave vertical antenna (from Radio Communications.)

and I am going to get back on the DX bands after a long, summer layoff".

"Now that we are getting into fall weather, you should notice a great improvement in 15 and 10 meters", I replied. "And the summertime static is rapidly dropping off on 40 and 80 meters. All in all, it looks like a great winter season for DX".

Doctor Liv pushed the magazine across the table to me. "This is a recent issue of *Radio Communication*, the monthly publication of the Radio Society of Great Britain. There's an interesting article on a simple quarter-wave 40 meter vertical beam by G3HCT (fig. 1). He uses a folded unipole about 34 feet long, with 3-1/2 inch spacing between the wires. It is operated against a good radial ground system. Three "sloper" reflector wires are used to obtain directivity and front-to-back ratio. The reflectors are about a half-wavelength (71 feet). Gain measurements were not made, but many comparative tests were run against a neighboring ham who had a two element 40 meter Yagi beam at 120 feet. This simple antenna, in the best direction, was only 1/2 to 1 S-unit down from the Yagi beam. In fact, G3HCT says it is the best 40 meter antenna he's ever used".

"What does he use for a matching network?", I asked. "I bet the feed-point resistance of that antenna is a lot higher than 50 ohms".

"Yes", replied Doctor Liv. "He used a stub matching system (fig. 2). The length E was determined by shorting through the coax line with a pin. When the correct spot was determined, the line was trimmed and the end shorted with a more permanent joint".

"That looks like an interesting antenna", I admitted. "More and more hams are experimenting with versions of the sloper antenna and it looks like it is evolving into one of the

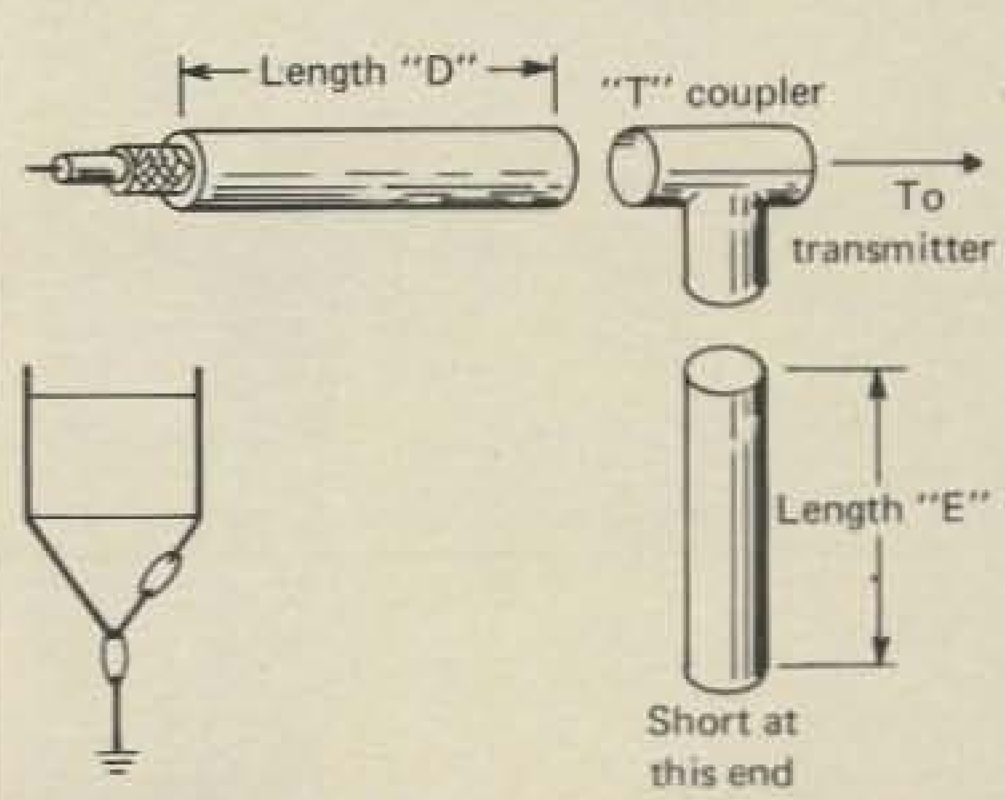

Fig. 2 - The coaxial matching system for the 40 meter beam. Length D is 16' 2" and length E is 9' 3" for 50 ohm cable (from Radio Communication.)

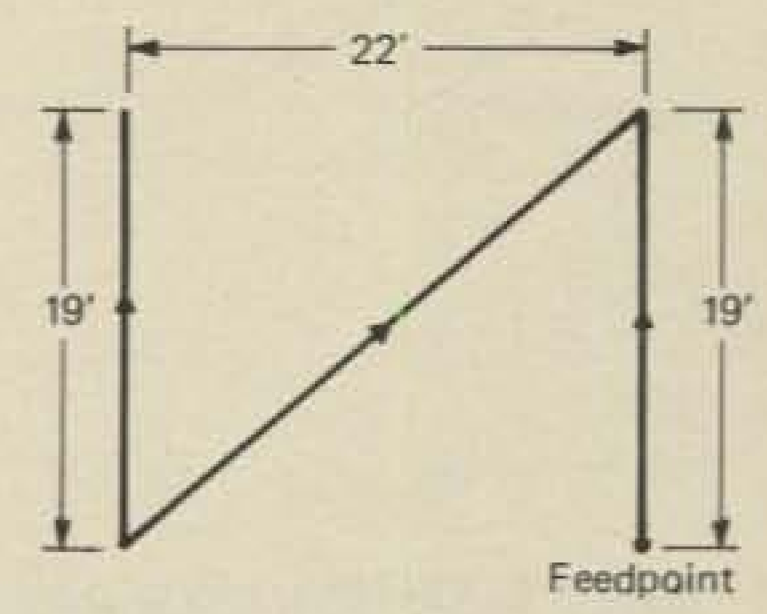

Fig. 3 - The zig-zag "sloper" antenna for 40 and 15 meters at G4GMX (from Radio Communication.)

more popular types."

Doctor Liv pointed to another illustration in *Radio Communication.*

"Here's another short note on a zig-zag sloper for 40 meters that was an offspring of the 160 meter design of VE7BS. This small antenna was built for 40 meters by G4GMX. He says that it works well not only on 40 meters but also on 15 meters, with the low points only a few feet above ground (fig. 3).

"On 40 meters this is a half-wave element, voltage fed from the base by means of a standard L-network (a series inductor and a parallel capacitor). On 15 meters the antenna forms a 3/2-wavelength system, providing good broadside directivity.

"And, finally, G3GMM points out the virtues of the 40 year old Bi-square antenna (fig. 4). He's revived this design, which is merely a loop (open at the top) that has two wavelengths of wire in it—as opposed to the Quad loop which has only one wavelength of wire. G3GMM uses two loops at right angles to each other and switches back and forth between them. Each antenna has a broad figure-8 pattern, so he gets nearly complete coverage with this simple system. The antenna is slung from a 40 foot pole and the dimensions for a 10 meter array are given in the drawing. The closed stubs are about a quarter-wave long, each loop being put on frequency by a dip-oscillator coupled to the stub. Radiation resistance is high and the antenna

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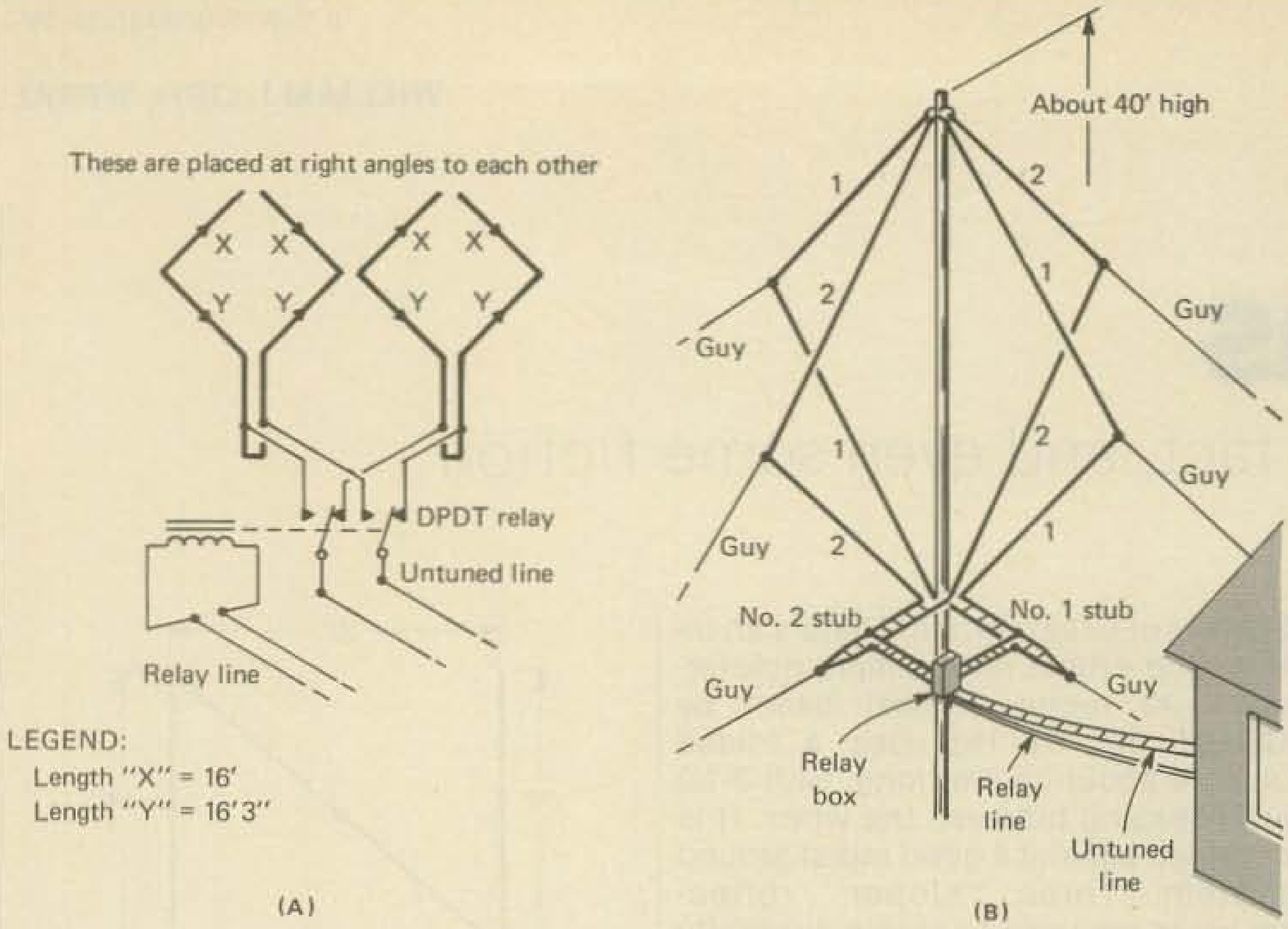

Fig. 4 - Radio G3GMM uses a pair of Bi-Square loops for full coverage. Large loop has about 4dB gain over a dipole. Quarter wave stub is used for good match to transmission line. Dimensions shown are for 10 meters. Loops are open at the top (from Radio Communication.)

provides excellent bandwidth. Of course, a 50 ohm line and 4-to-1 balun may be substituted for the open wire transmission line."

"I remember that antenna", I said. "While not many hams use it, it is one of the best wire beams that can be slung from a single pole. In this case, the gain of the big loop is about 4 dB over a dipole."

Doctor Liv leaned back in his chair and said, "Well, I have exhausted my antenna ideas. What do you have to offer me?"

"I just returned from Washington", I said, "And I had a good chat with K4VX, one of the big-gun DXers on the East Coast. He excels in 80 meter DX and has worked with a lot of antennas on that band. His primary antenna is a three element 40 meter beam on a 130 foot steel tower and he's hung many 80 meter antennas from that tower—slopers, dipoles, delta loops, inverted V's and lots more.

"About a year ago Griff was experimenting with an 80 meter inverted-V suspended near the top of the tower. While adjusting the wire lengths to resonance at about 3.8 MHz. he noticed that there was interaction between the 40 meter rotary beam and the inverted-V. In fact, the SWR of the V varied from 1-to-1 when the boom of the Yagi was perpendicular to the plane of the inverted-V to nearly 6-to-1 when the boom was parallel to the inverted-V. Obviously the 40 meter beam possessed boom resonance somewhere in the 80 meter band!

"So Griff took down the inverted-V and decided to put the boom resonance to work on 80 meters. He fabricated a 15 foot long gamma match rod out of 1-inch diameter aluminum tubing and constructed a gamma matching capacitor of 450 pF (a 250 pF variable capacitor in parallel with a 200 pF transmitting mica capacitor). He put the matching device on the boom, tweaked the capacitor and loaded the 40 meter boom on 80 meters with a resulting SWR of about 1.2-to-1 for starters!"

"Interesting", said Doctor Liv as he looked at the photograph of the installation (fig. 5).

"Well, K4VX's 40 meter beam is home-built on a 48 foot boom with no insulation between elements and boom. The reflector is 70′8″ long and the director is 64′0″ long. These elements act like two capacity loading "hats" on the boom at 3.8 MHz. Starting at the center of the boom, the distance out to one tip of the reflector is about 59 feet. The distance out to the tip of the director is about 56 feet. This produces a physical length of the 80 meter antenna element of 116 feet. But since there is tubing going in two directions in the "hat" (the parasitic 40 meter element, that is,) the electrical length on 80 meters is slightly longer. Incidentally, the length of the 40 meter driven element has little or no effect upon the resonance of the boom and produces no interaction.

"The 80 meter SWR curve of the 80 meter loaded boom-dipole is shown in fig. 6. It runs about 200 kHz. between the 2-to-1 SWR points, which is very good.

"Griff points out that not everyone has a full sized 40 meter rotary Yagi on a 130 foot tower to play boom matching games with; however the same principles should apply to 20 meter beams or large tribanders for adaptation to rotary 40 meter dipoles. There

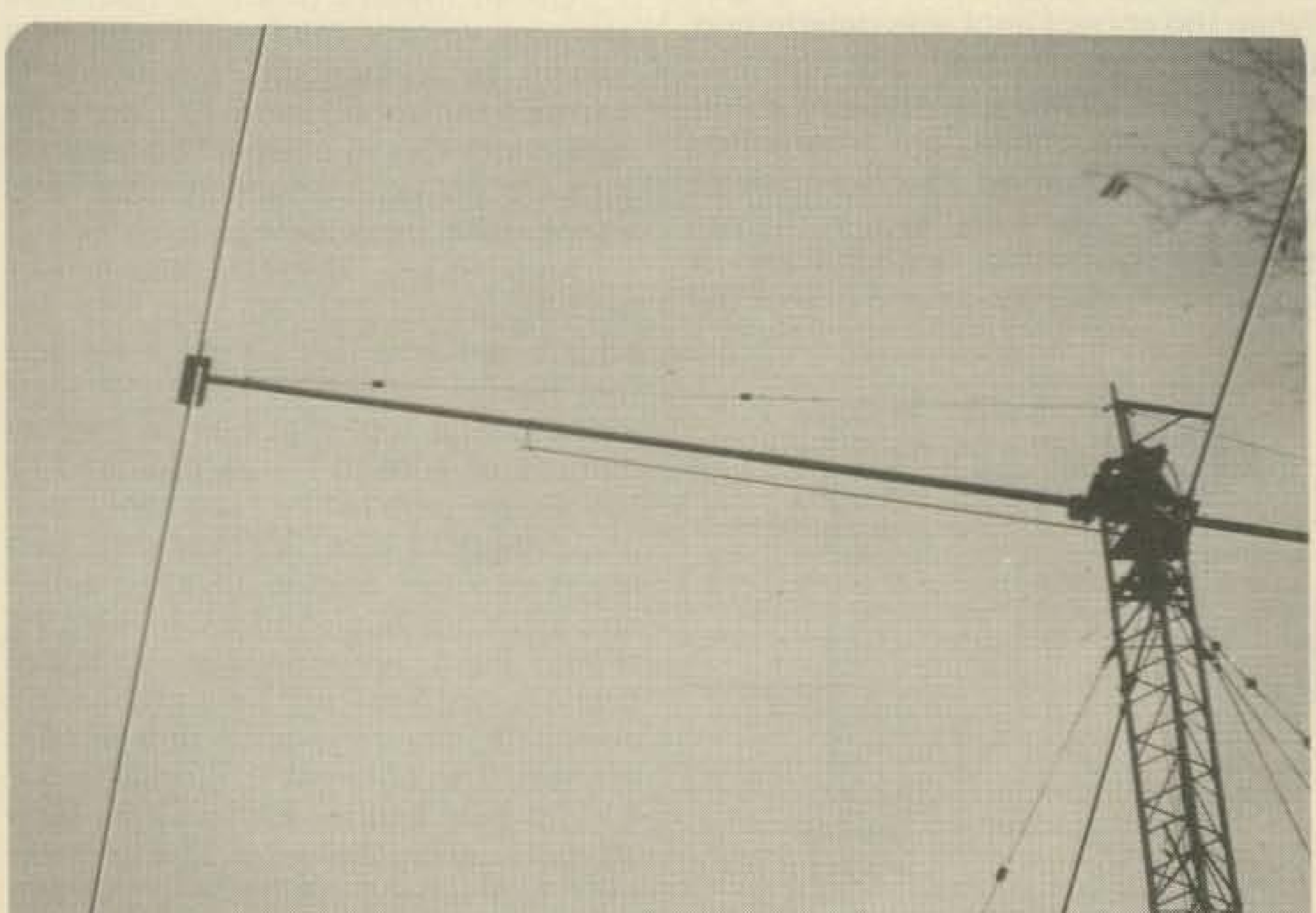

Fig. 5 - The 40 meter beam at K4VX also serves as an 80 meter dipole. Boom is end-loaded by 40 meter elements and is matched to 50 ohm line by means of a gamma match rod shown below the boom.

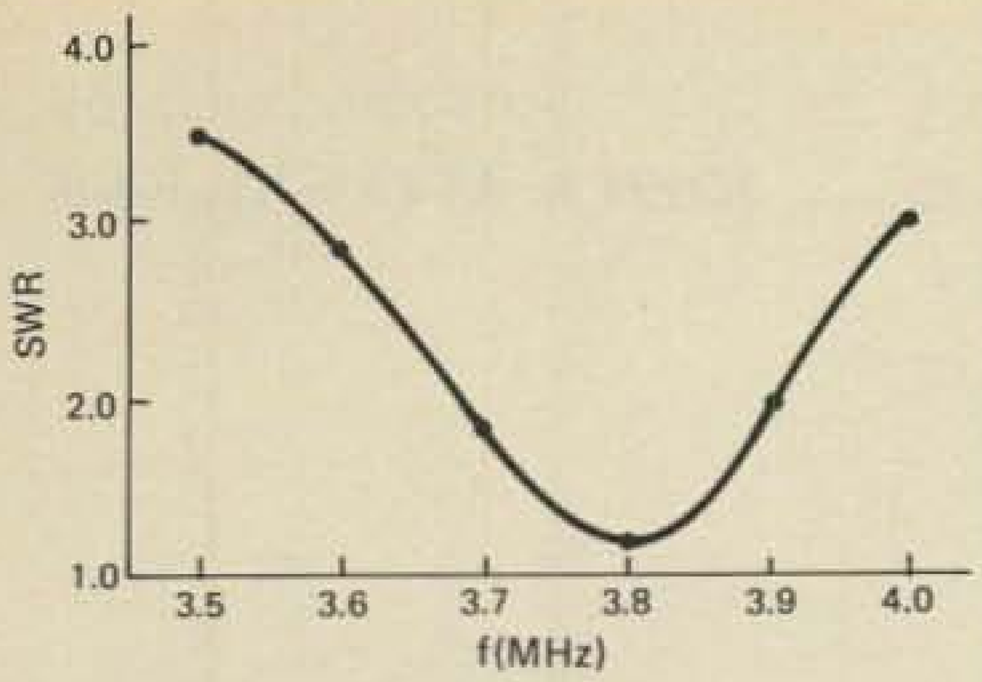

Fig. 6 - The SWR curve of the boom-loaded 80 meter antenna at K4VX.

are literally thousands of amateurs with antennas that could be adapted to become rotary dipoles on 40 meters. The TH-6 and TA-36 beams should be capable of being boom-matched for 40 meters with no modification other than the addition of a gamma match. The 204-BA is another likely candidate.

"Another idea which bears investigation is to use insulated boom to element mounts on the parasitic elements and then insert loading coils or capacitors (as applicable) to make the electrical boom-plus-element length resonant at a lower band than used by the Yagi. Using this technique, correct resonance could be produced with almost any combination of boom and element length."

Doctor Liv smiled and said, "I think that's a great idea and can be adapted to make almost any beam work on a lower band. But what about the fellow who doesn't have a beam?"

Before I could reply, he answered his own question. "I've got a letter from W4BV. Buck tried out the G3NGD multiband antenna idea that you reprinted from *Radio Communication* in your January, 1977 column in *CQ*. The antenna looked like fig. 7. A 33 foot mast was used for 40 meters and a top wire had two traps: one for 80 meter operation atop the mast and one for 160 meter operation placed in the horizontal wire.

"Well, W4BV tried this stunt. He had a 4-BTV vertical for 10 to 40 meter operation. He built a lightweight version of the traps using B&W inductors and used No. 16 wire for the flat top to reduce the wind load. The drawing of the original G3GND trap is shown in fig. 8. The 40 meter trap is dipped to 7.1 MHz and the 80 meter trap is dipped to 3.7 MHz. Exact antenna resonance is determined by adjustment of the flat top. The 80 meter section is adjusted first. Buck reports that he's worked W7 and W7 stations on 160 meters with this simple antenna—using a good ground system, of course."

"That should work well", I said. "This is a good idea to get a simple six band antenna in a small space."

"You read a lot about big antennas but most amateurs use quite simple antennas. I think there are more ground planes and dipoles than Monster Quads", remarked my friend. He turned to me and said, "Did you read the fine article on Quads versus Yagis by N6NB in the May issue of *ham radio* magazine? I found it very interesting. What do you think of his conclusions?"

I laughed. "You're not going to draw me into the old argument about which antenna is best—the Yagi or the Quad. There's a lot to be said for each antenna design. Wayne has made an important contribution to the discussion and all DX-minded hams should read his article.

"There's a lot of dangers in measuring antenna gain and trying to draw conclusions from antenna measurements between antenna types is like walking through a minefield. Wayne didn't step on any mines, however, and he has some pretty impressive measurements on many different antennas.

"A lot remains to be learned about the Quad. For example, some amateurs have found unwanted boom resonance in a large Quad array. I received a letter some time ago from an amateur who had a four element Quad on a crank-up tower. He had the tower down at 20 feet to do some maintenance on the antenna. By chance he was standing atop a tall ladder and touched the end of the boom near the director while the antenna was being fed a little power through an SWR meter. He was surprised to see the SWR change when he touched the boom. Normally the boom is assumed to be "cold" and doesn't affect antenna operation. How do you account for the change in SWR when the outer end of the boom is touched?"

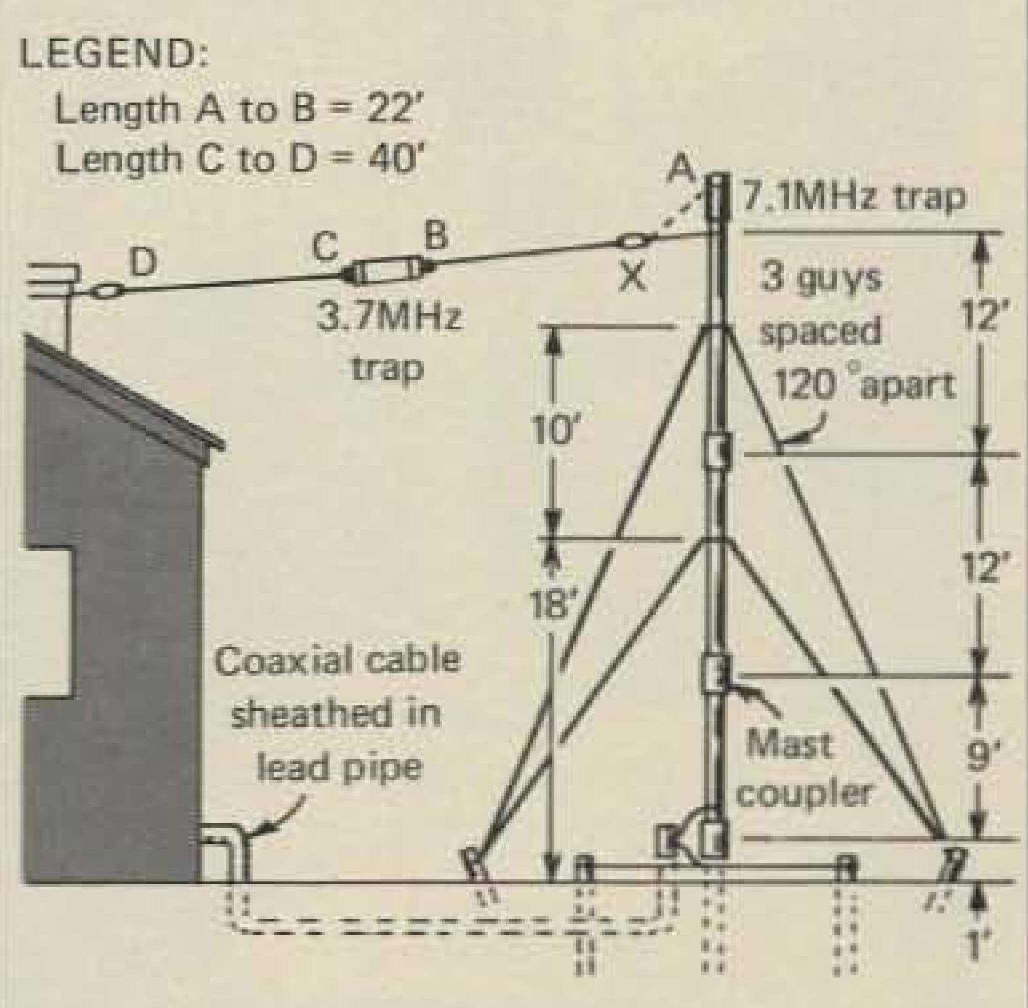

Fig. 7 - The original G3GND all-band (10-160 meters) antenna. It has been modified by W4BV. He uses a 4-BTV vertical with traps using B&W inductors.

"I don't know", admitted Doctor Liv. "I imagine the boom must be coupled to the Quad loops in some fashion."

"It might be that the Quad spider and metallic Quad arms are interfering with proper antenna operation. I know that long aluminum arms can ruin Quad operation. But how about short arms? Many Quads use an aluminum spider that has short stub arms to which fiberglass poles are attached. How long can the stub arms be before you get into trouble? I don't know."

"Beats me", said the Doc. "But it looks as if the physical assembly of the Quad, particularly the amount of metal in the plane of the loops, has more to do with operation of this antenna than has been previously thought. I hope Wayne and other experimenters can come up with some of the answers. But that's what makes antenna work so fascinating. As far as many hams are concerned, the design of an antenna is the last frontier in the exciting world of amateur radio!"

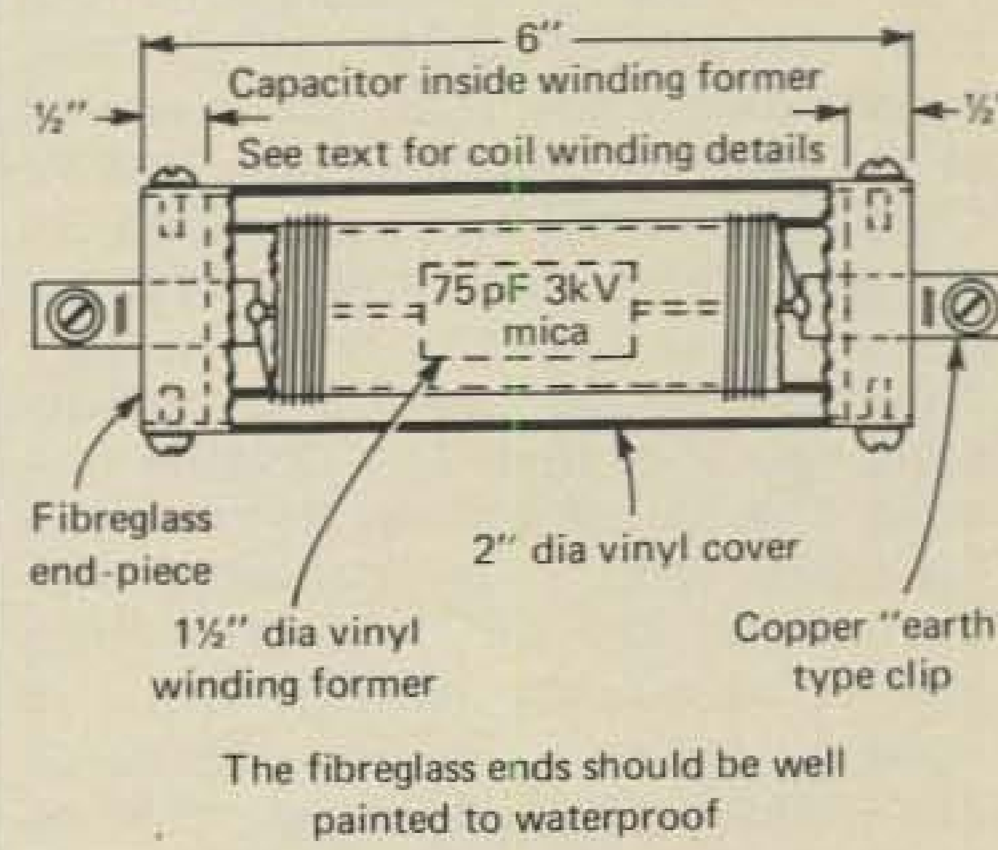

Fig. 8 - The original G3GND trap. Coil is 40 turns No. 20 enamel wire spaced wire diameter on 1½" diameter form. Turns are adjusted for resonance at 3.7 MHz. The 40 meter trap consists of 20 turns No. 16 enamel wire on 1½" diameter form, close-spaced. Trap is adjusted for resonance at 7.1 MHz. Drawings from Radio Communications, a RSGB publication.

(Those amateurs interested in more information on the Cubical Quad antenna should take note of the publication "All About Cubical Quad Antennas", by W6SAI. It is available for $4.75 plus 75¢ postage and handling from Radio Publications, Inc., Box 149, Wilton, CT 06897.)

For more information on *Radio Communication* magazine, contact the Radio Society of Great Britain, 35 Doughty St., London WC1N 2AE, England.

a monthly feature by

WILLIAM I. ORR, W6SAI

Antennas

Design, construction, fact, and even some fiction

"This place has been like a morgue", I said, glancing at Pendergast who has stopped by for a chat on his way home. "Where are Doctor Liv and Johnathan Cadaver?"

"They went to the Ham Convention", replied Pendergast with a sigh. "Personally, I'm pooped out on conventions."

I did not reply, so he continued," Want to know what Fukui Makota said about conventions?"

"Who's he?", I rejoined. "Never heard of him."

"Well, Fukui Makota was the Japanese Commissioner to the Philadelphia Exposition of 1876. After visiting the Exposition, he said, 'The crowds come like sheep, run here, run there, run everywhere. One man start, one thousand follow. Nobody can see anything, nobody can do anything. All rush, push, tear, shout, make plenty noise, say damn great many times, get very tired, and go home'. That's what the Ham Convention was like."

I sighed." I agree. Guess I am getting old. However, something good often comes out of Conventions. Especially the Technical Symposiums. I remember there was a very interesting paper presented at the 1975 ARRL National Convention by Ralph Robinson, W3IOA, who is at the Applied Physics Laboratory of John Hopkins University. Ralph holds the patents on several interesting aircraft antennas, and has developed a method of feeding a ham tower on various low frequency bands. Ralph Ladd, W3KA, was kind enough to send me a copy of the W3IOA presentation. It may be of interest to you."

I tossed Pendergast a impressive booklet that had been distributed at the Convention. "W3IOA has had this antenna design up for about 3 years now and has had good DX results on 80 meters. In essence, the installation is an elevated vertical dipole which does not require a ground plane or radial wires.

"The basic antenna installation at W3IOA is a triband Yagi for 20-15-10 meters mounted atop a freestanding *Rohn-Spaulding HDX-48* tower (fig. 1). Atop the tribander is a *Ringo Ranger* 2 meter antenna, and both antennas are mounted atop a 5 foot mast extending above the tower. The overall height of the installation is 61 feet.

"The idea is to transform the tower and high frequency antennas into a vertical dipole by the use of attachments called "isolators" and "exciters" which are shortened quarter-wave sections attached to the tower (fig. 2). The isolator elements control the flow of rf current in the tower legs and thus isolate the tower from ground on 80 meters. One isolator is used for each leg of the tower and is tuned to a specific spot in the 80 meter band.

"The elevated vertical antenna is excited in its central portion by another shortened quarter-wave section attached to the tower. This device is the exciter. A 50 ohm transmission line is tapped on the isolator element.

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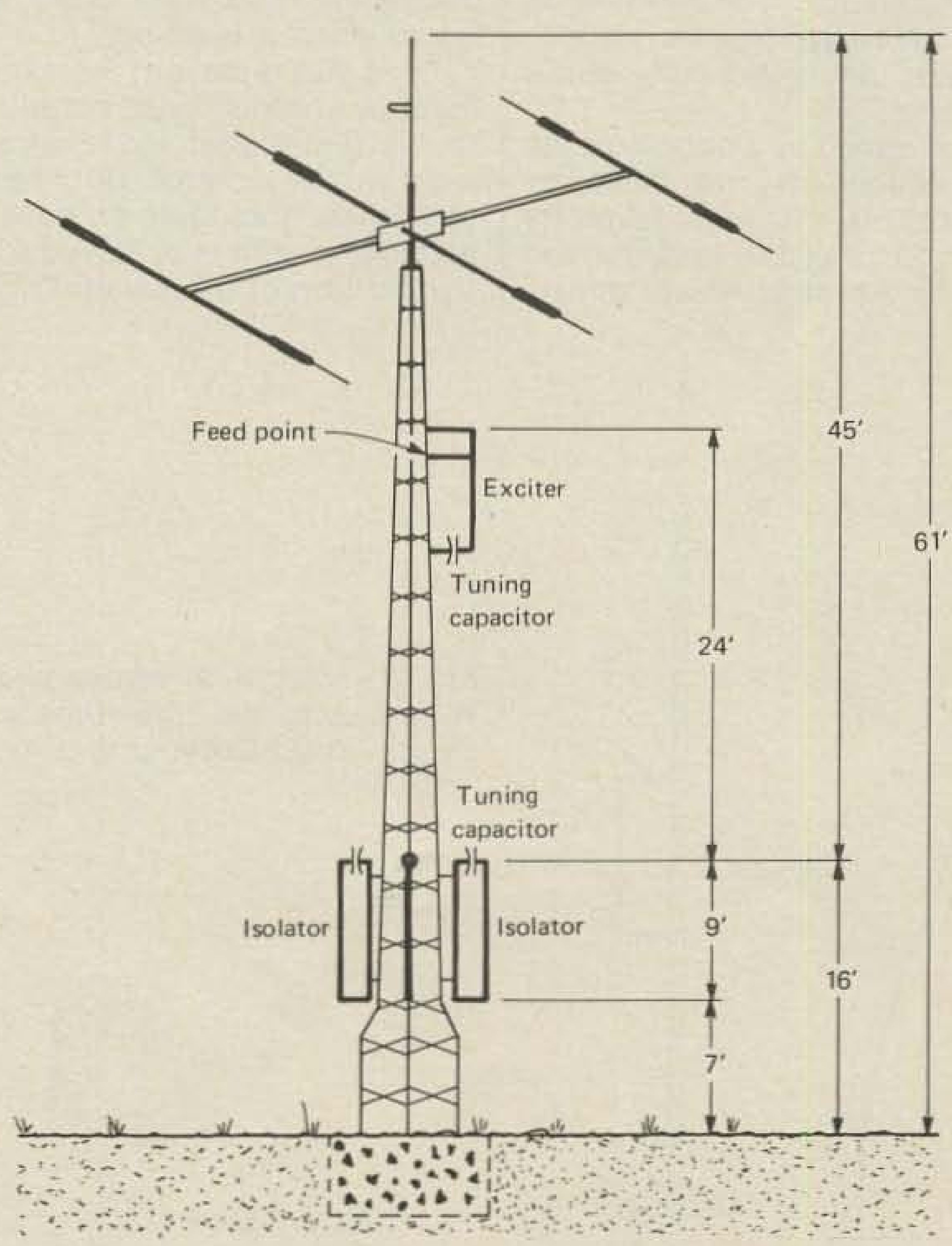

Fig. 1 - The multiband antenna installation at W3IOA. A tribander beam covers 20, 15 and 10 meters, with a 2 meter vertical antenna mounted atop it. The tower is used as a half-wave vertical antenna for either 40 or 80 meters by the addition of "isolators" (one for each tower leg and and "exciter". The exciter is a modified gamma match that provides a transformation from the tower impedance to a 50 ohm transmission line. (Drawing courtesy of W3IOA and W3KA).

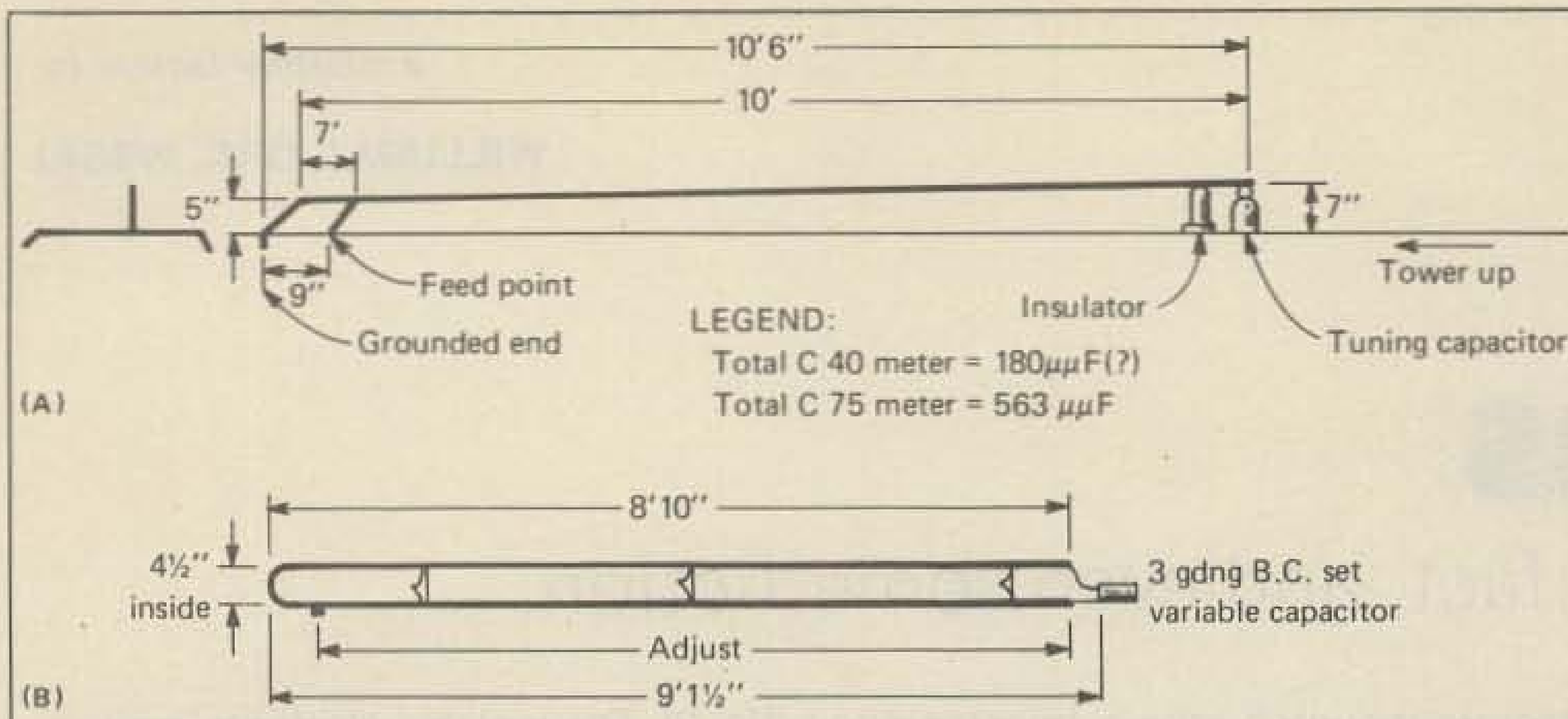

Fig. 2 - Drawing of shunt-fed exciter and isolator elements. Although shown in a horizontal position, devices are mounted vertically on the tower legs, as shown in fig. 1. Length of devices was determined by experiment. Exciter device is attached to the tower at its upper end and held away from the tower by a 7" insulator at the bottom end. A vacuum variable tuning capacitor was used on the exciter element. (Drawing courtesy of W3IOA and W3KA).

"And electrical representation of the W3IOA antenna is shown in fig. 3. The isolator is represented by a parallel resonant circuit (a trap, if you wish to call it that) which presents a high impedance to r.f. energy at its resonant frequency. The isolator is quite short in relation to a wavelength at 80 meters, being typically about nine feet long.

"The dipole formed by a portion of the tower is raised off the earth by distance *d*. This distance is pretty much the choice of the installer and depends somewhat on tower dimensions. In any event, it helps to remove the antenna from the vicinity of the ground and thus reduces ground losses."

"How is the antenna excited?", asked my friend as he looked at the diagrams." You can't break a tower leg to insert a feedline."

"You can represent the exciter element by another tuned circuit. It is, in fact a distributed inductance, as is used in the isolator. But the tapped coil gives the idea of how an impedance match is achieved to the active portion of the tower. This device is very short, compared to the wavelength at 80 meters, being about ten feet long".

Pendergast frowned. "The exciter element looks like a gamma matching section to me", he observed.

"Not quite", I replied. "But you have the right idea. Notice that both the exciter and the isolator are tuned to frequency by means of a variable capacitor at the 'hot' end of the assembly. W3IOA used variable vacuum capacitors in his installation. He adjusted the devices before he put them on the tower."

"How did he do that?", demanded Pendergast, as he began to make notes and drawings in his ever-present notebook.

"The devices are constructed of half-inch diameter copper tubing, right-angle joints and T-joints purchased from a plumbing store. For starters, the resonator is suspended in the clear, about eye level and is resonated by a 3-gang broadcast tuning capacitor. To get the reasonator on frequency, it was excited by a signal generator coupled by a link coupled to the shorted end of the device. A high impedance pick-up rf volmeter is coupled to the 'hot end,' and the capacitor is tuned for maximum voltage. Once the required capacitance is found, the value is logged for future use. The exciter is attached to a tower leg by means of a cross bar whose flattened ends have holes drilled to match the bolt holes used to assemble the tower. Both are tinned before assembly so that similar metals are in contact with each other. The 'hot' end of the isolator is supported by a long ceramic insulator. The variable vacuum capacitor—a fragile item—is connected across the insulator to protect it from mechanical stress. The capacitor is pre-set to the capacitance determined in the test just completed.

"The isolator is placed at a location estimated, by eyeball, to be near the mid-point of the 80 meter dipole. Ralph put it where it is because there were some pre-drilled bolt holes in the tower at about the right point.

"The isolator is attached to the tower at its upper end using a copper T. The rod is held away from the tower at the lower end by a 7-inch long insulator. The spacing of this isolator section, incidentally, bears an inverse relationship to the value of capacitance required for resonance.

"Gosh", said Pendergast. "Does this idea work on any tower?"

"Well, Ralph states that it would be a rare coincidence if all, or even a few, of the physical dimensions selected for his installation were the ultimate

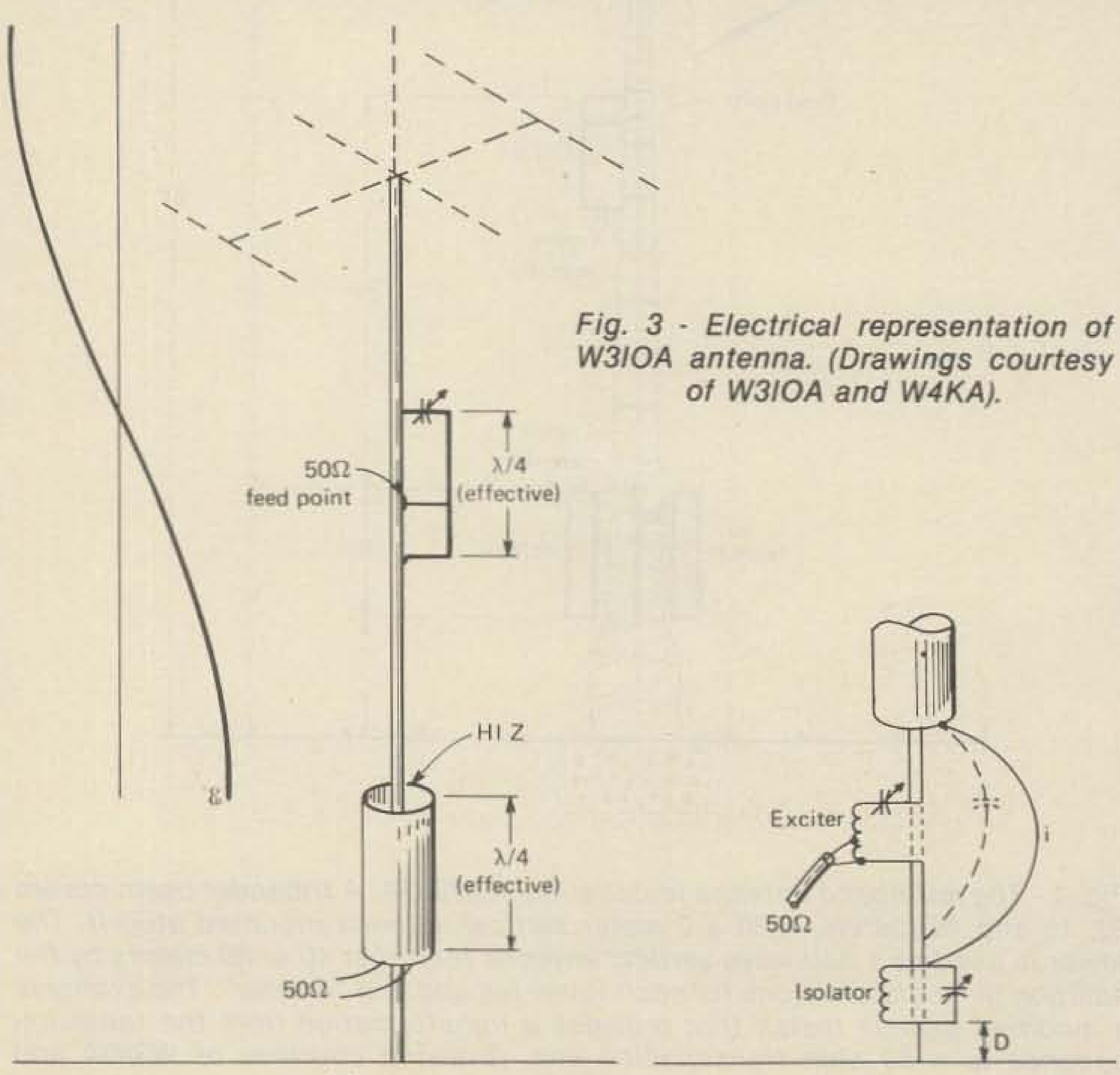

Fig. 3 - Electrical representation of W3IOA antenna. (Drawings courtesy of W3IOA and W4KA).

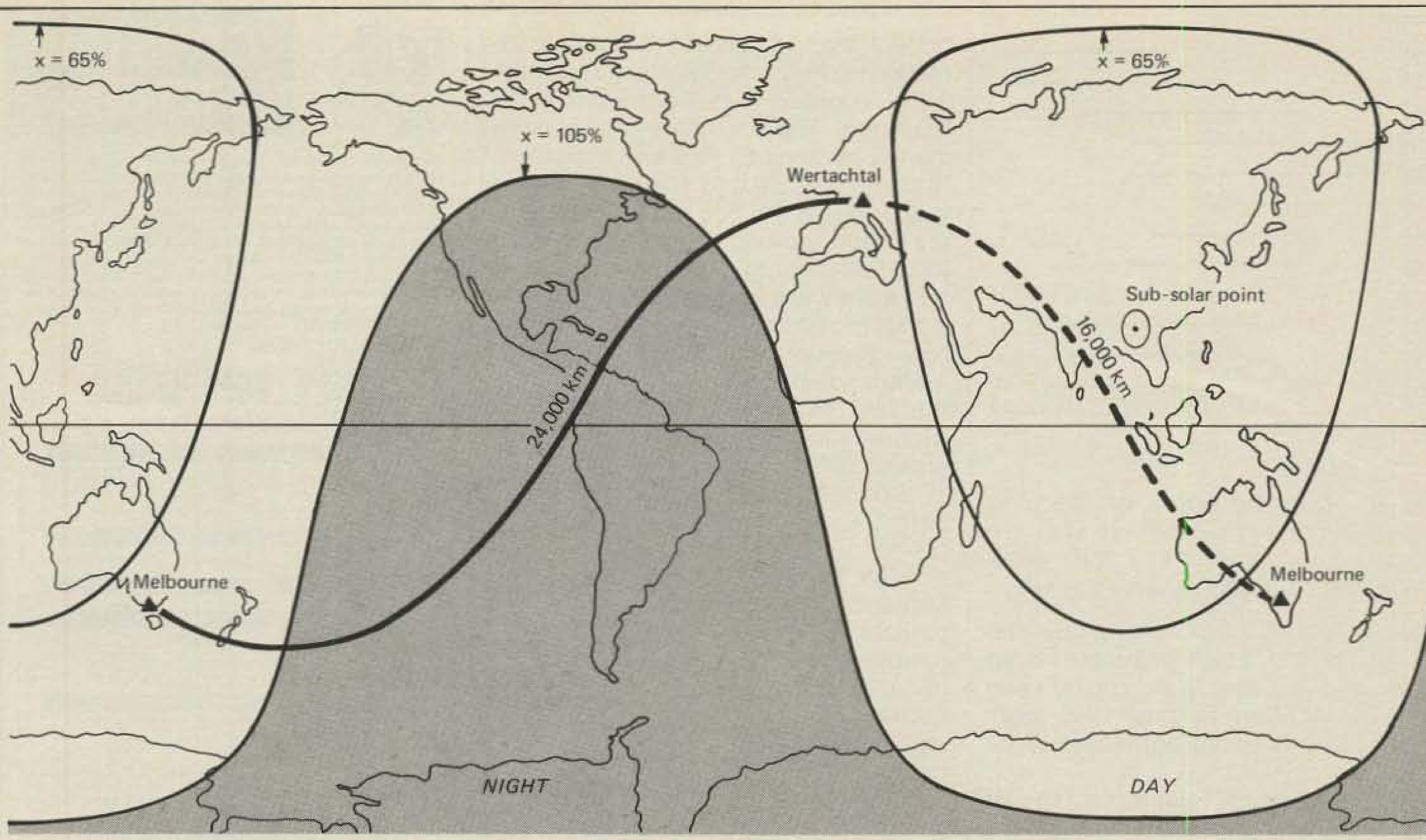

Fig. 4 - Short and long Great Circle paths between Germany and Australia with day and night zones indicated. X is the sun's Zenith angle. (Drawing courtesy of Telecommunications Journal.

of optimizations. But the important consideration is that, taken as a whole, the system works!"

"Are there any adjustments after the units are on the tower?", asked Pendergast, as he scribbled away.

"Yes, you have to fine-tune the isolators. You couple a signal generator to the "cold" end and tune the isolator for maximum voltage in a r.f. voltmeter coupled to the 'hot' end. The last adjustment is tune the exciter element for low s.w.r. on the feedline. Of course, this is only a quick run-down, and if you want more information about the system you might write to either W3KA or W3IOA, inclosing a stamped, self-addressed envelope. They might be able to provide more details.

"Right", declared my friend. "I might just do that."

I tossed a magazine to Pendergast who caught it deftly without missing a word he was inscribing in his notebook.

"This is a recent copy of the *Telecommunication Journal,* published by the International Telecommunications Union in Geneva, Switzerland, I said. "There's a very interesting aricle in the propagation of the long distance signals between Germnay and Australia via the short and long paths on 9 MHz and 21 MHz. It concerns itself with reception of shortwave broadcast signals, but the information applies equally to amateur transmissions. The great circle and long path are shown in fig. 4. Note that the long path travels through a zone of darkness (the shaded area) while the short path travels through sunlight. Here is a condensation of what the article says.

"In order to reach listeners in Australia during the evening hours it is necessary to broadcast during the European morning time. The short cicle path is illuminated by the sun which implies high ionospheric absorption in addition to the path attenuation. On the other hand, the long great circle path in its major parts passes through the dark hemisphere so that considerably less signal absorption is encountered. Morover, the maximum usable frequency (MUF), which also depends upon the position of the sun, is lower for the long path than for the short path. On the 9 MHz band, this path was successful for the year and the results found on the two frequencies, expressed as a percentage of satisfactory reception are shown in fig. 5.

"The authors of the article state that they were originally encouraged to try these tests because of the experience of radio amateurs in using long path circuits successfully.

"Opening hours of the long path at 7 MHz and 9 MHz during all months of 1958 are shown in fig. 6. It looks as if the spring months are the best for the DL-VK path, with May showing a long path opening of nearly four hours, starting about 0425 Zulu and running to 0800 Zulu. Notice that as summer and fall approached, the open period for long path transmission grew progressively shorter and the openings appeared later each month. The shortest long path opening occurred in December for a period of about two hours from 0715 Zulu to 0915 Zulu.

"There are more long path openings than one might think. For example, there's a West Coast (W6) opening just at sunrise during the winter months (about 1530 Zulu) via the long path to Europe on 80 meters. You can

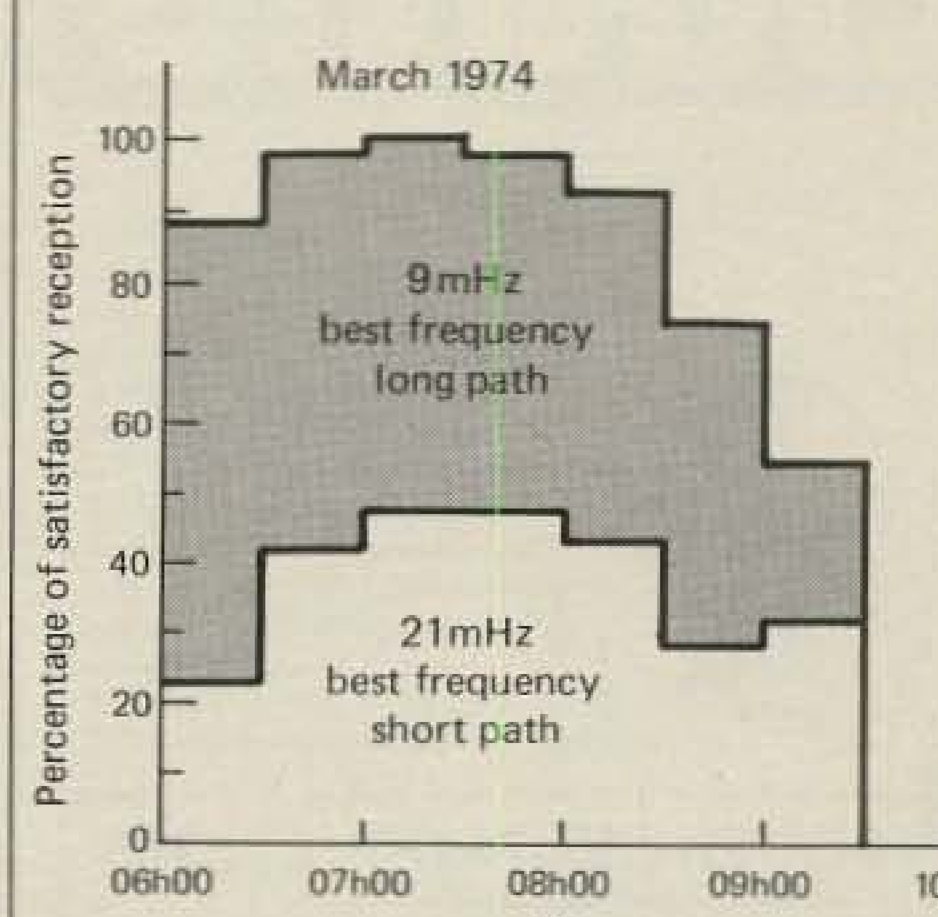

Fig. 5 - Percentage of satisfactory reception via the short and long great Circle paths (from the Telecommunications Journal).

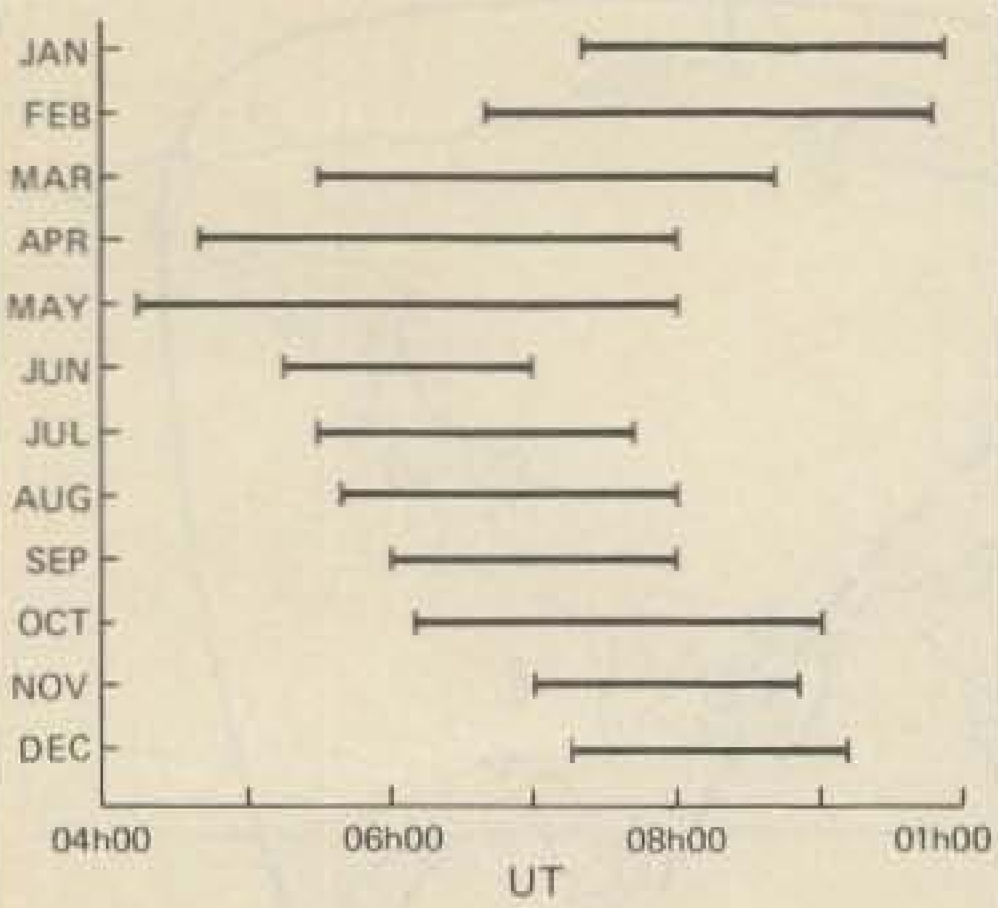

Fig. 6 - Opening hours of the long Great Circle path between Western Europe and Australia at 7 MHz (from the Telecommunication Journal).

hear a lot of European s.s.b. just below 3.8 MHz. The signals are rather weak, and you need a good beam and a quiet location to hear and work them, but it is being done by a lot of DX'ers.

"Too few hams take advantage of the long path. Some of them do, and they work a lot of DX. I just received a letter from a DX'er in New Jersey who reports good 10 meter long path openings during last spring. The openings were to Japan, Australia, Indonesia and Siberia. In March there was an excellent opening about 0345 Zulu to Malaysia (9M2) and Western Australia (VK6). Very few W stations were on for that one. Then in April there were many openings to VK6 and Japan between 1100 Zulu and 1330 Zulu. There was an excellent one on April 17 when my friend worked VK6 on s.s.b. the long path, using a converted CB rig and a 5/8-wave vertical antenna.

"More recently, the long path from New Jersey to the Far East on 10 meters has been closed, but he noted that EA7PW in Spain was able to work Australia long path (through the USA) around 0500 Zulu. That was in July."

"Sounds as there's a lot of long path DX on all bands", observed my friend.

"Yes. Some years ago I operated in Monaco (3A-land). I found the long path to California opened within five minutes of 1715 Zulu each day. It was uncanny. I knew that I could hear California and could almost set my watch by the long path opening. At first I would hear Southern California. San Diego would come in, followed in 10 minutes or so by Los Angeles. The skip would move up the West Coast, the Los Angeles fellows dropping out as I started to work the San Francisco gang. Then I would hear Portland, Oregon, and finally Washington and British Columbia.

"If conditions were exceptionally good, the long path skip would then swing about and turn down south once again, only it would be inland: I would work Salt Lake City and then finally, just before the band dropped out, I could work Tucson, Arizon. The long skip seemed to follow an elliptical path—south to north then back down south again. The whole cycle seemed to take about 30 to 45 minutes.

"DX'ers would be wise to keep notes of long path openings in their area. As you can see, it's sometimes easier to work DX via the long path than it is by the conventional, short Great Circle path."

Pendergast executed an ear-splitting yawn. "It's about time I went home", he admitted. "Anything else new?"

"I think I hold the world's record for a delayed QSL card", I said." In the fall of 1938 I worked XX2JQ, a maritime-mobile station enroute from Calcutta to Europe. He was in the Mediterranean at the time. I just got the QSL card a few months ago. I met Johnny, ZL2AM, a few months ago and found to my surprise that he was old ZL2JQ and worked clandestine XX2JQ on the *City of Marseilles* in '38. The ship was later sunk in Ceylon harbor in 1942. In any event, John confirmed the contact and dug up an old XX2JQ QSL card for me. It is now one of my prized confirmations—forty one years after the QSO. Can you beat that?"

"No", admitted my friend." But I'm still trying to get a QSL card from the first station I worked as a Novice".

Note- Interested in DX antennas that work? Suggested reading is the new *Radio Amateur Antenna Handbook*, by W6SAI and W2LX. Latest information and dimensions on all types of antennas that you can build. Write to Box 149, Wilton, CT 06897 for full details.

a monthly feature by

WILLIAM I. ORR, W6SAI

Antennas

Design, construction, fact, and even some fiction

"What's up, Doc?" I asked.

Doctor Livingston I. Presume frowned and said, "Knock it off! I don't like to hear that a thousand times a day."

"My, we're a bit touchy, aren't we?" I asked.

Doc Liv smiled and shrugged. "I guess so. Pendergast was supposed to come over today and help me put up my new 10 meter beam. But he didn't show up. So everything grinds to a halt until next weekend."

"Ah, yes," I replied. "He's een seeing a lot of his buxom Vietnamese girl friend, How Bout Diem. I'm afraid he's lost to amateur radio and DX for a while."

Doctor Liv sighed and handed me a small envelope. "When do we get ready for the antenna party? I plan to incorporate the new matching device that Larry, KA9ACN, has worked out for a Yagi beam. Larry has his new Omega match on his stacked 10 and 15 meter beams (fig. 1). The match is waterproof and foolproof and this one model covers a range of 25 MHz to 33 MHz by simple adjustment. What do you think of it?"

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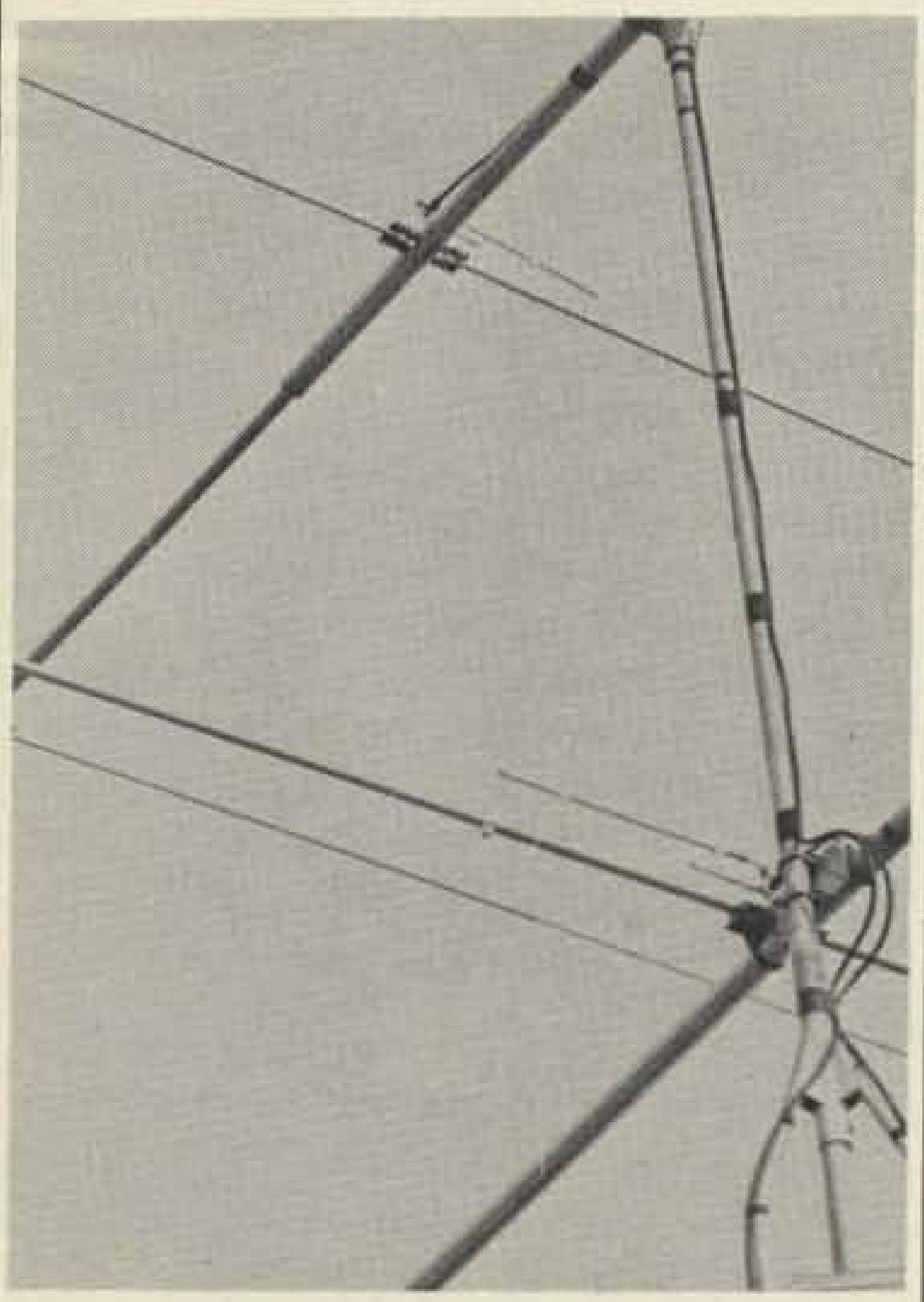


Fig. 1-The new Omega match assembly at KA9ACN. Larry has refined this match into a compact design and uses it on his stacked 10 and 15 meter beams. Each antenna is fed with a separate coaxial line. Detail of the assembly is shown in fig. 2.

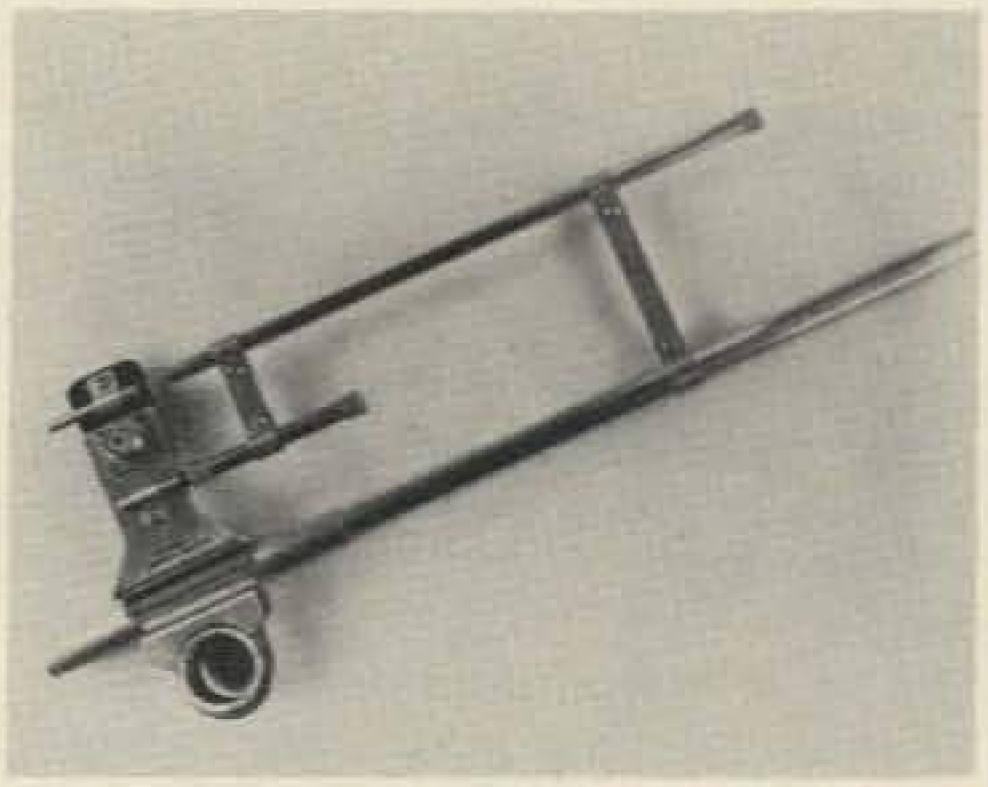
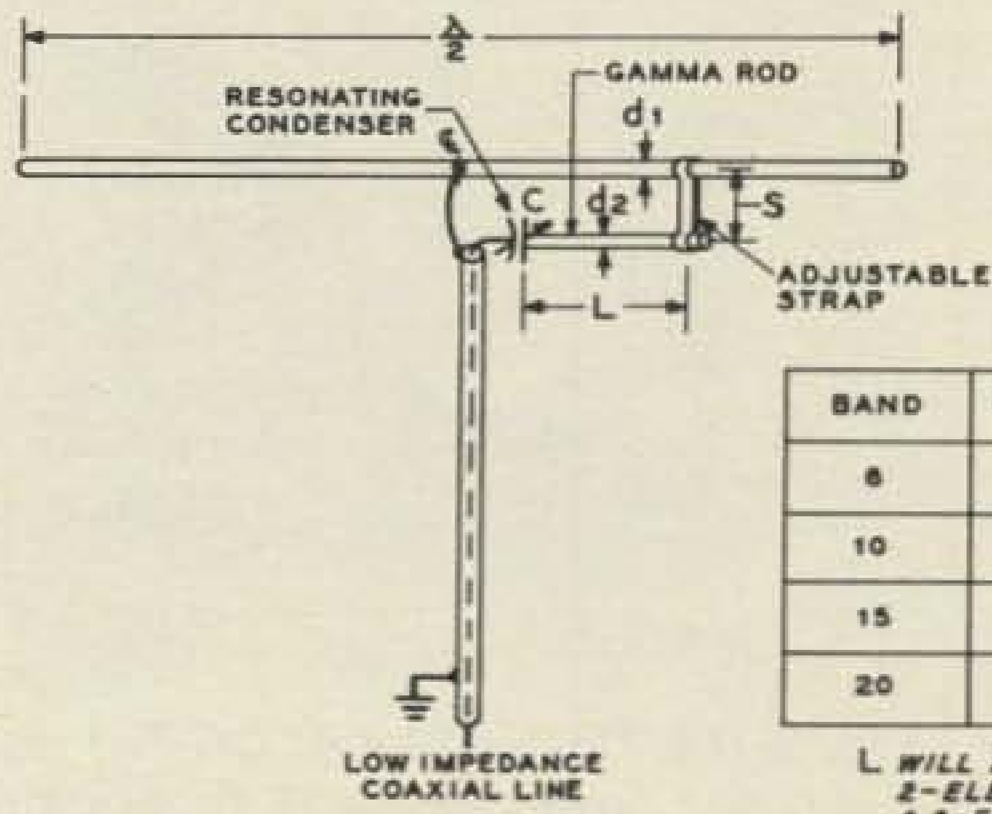


Fig. 2-A mechanical mockup of the KA9ACN Omega match. The match rod and integral, coaxial capacitor is between the coax plug and the driven element. This view is as if you are looking end-on, down the boom, at the center section of the driven element.

I looked closely at the photograph. "The Omega match is a refined version of the Gamma match," I observed. "Both systems are used to match a coaxial line to a driven element. The Gamma match consists of a single rod (running parallel to the element) and a series resonating capacitor (fig. 2). The outer shield of the coax line is grounded to the center point of the element. The inner conductor is connected to the Gamma capacitor. Lengths, spacings and capacitance values for the various amateur bands are shown in the illustration. This is a very effective and simple method of matching a coax line to a Yagi beam driven element.

"One problem that exists with the Gamma match is that the Gamma rod is quite long for 20 and 40 meter antennas. This means that the experimenter must lean out from the tower to move the adjustable shorting bar at the end of the rod.

"Gamma rod length can be reduced by means of a shunt capacitor as shown in fig. 3. This is the Omega match. Match adjustment, instead of being made by changing the length of the rod, is accomplished by varying the Omega capacitor. The capacitor is at a high impedance point in the matching device and permits an impedance variation at the point the coax is attached of about two-to-one. Thus, the adjustable shorting bar can be roughly set before the antenna is erected and then the match fine-tuned



FOR 52 Ω COAXIAL LINE

BAND	C MAX	L (INCHES)	S (INCHES)	d_1 (INCHES)	d_2 (INCHES)
6	25	12–14	3	1	$\frac{3}{16}$
10	45	20–24	4	$1-1\frac{1}{2}$	$\frac{1}{4}$
15	70	30–36	5	1	$\frac{3}{8}$
20	130	40–48	6	$1\frac{1}{2}$	$\frac{1}{2}$

L WILL APPROXIMATE THE SHORTER DIMENSION IN A 2-ELEMENT ARRAY, AND THE LONGER DIMENSION IN A 3-ELEMENT ARRAY.

Fig. 3-The basic Gamma match. This device matches a coaxial line to a dipole element. Length of gamma rod, spacing from element and diameter of rod are adjusted to provide correct impedance match. Series capacitor tunes out rod reactance. Suggested dimensions for high frequency amateur bands are shown in the drawing. (Courtesy of Radio Publications, Inc.)

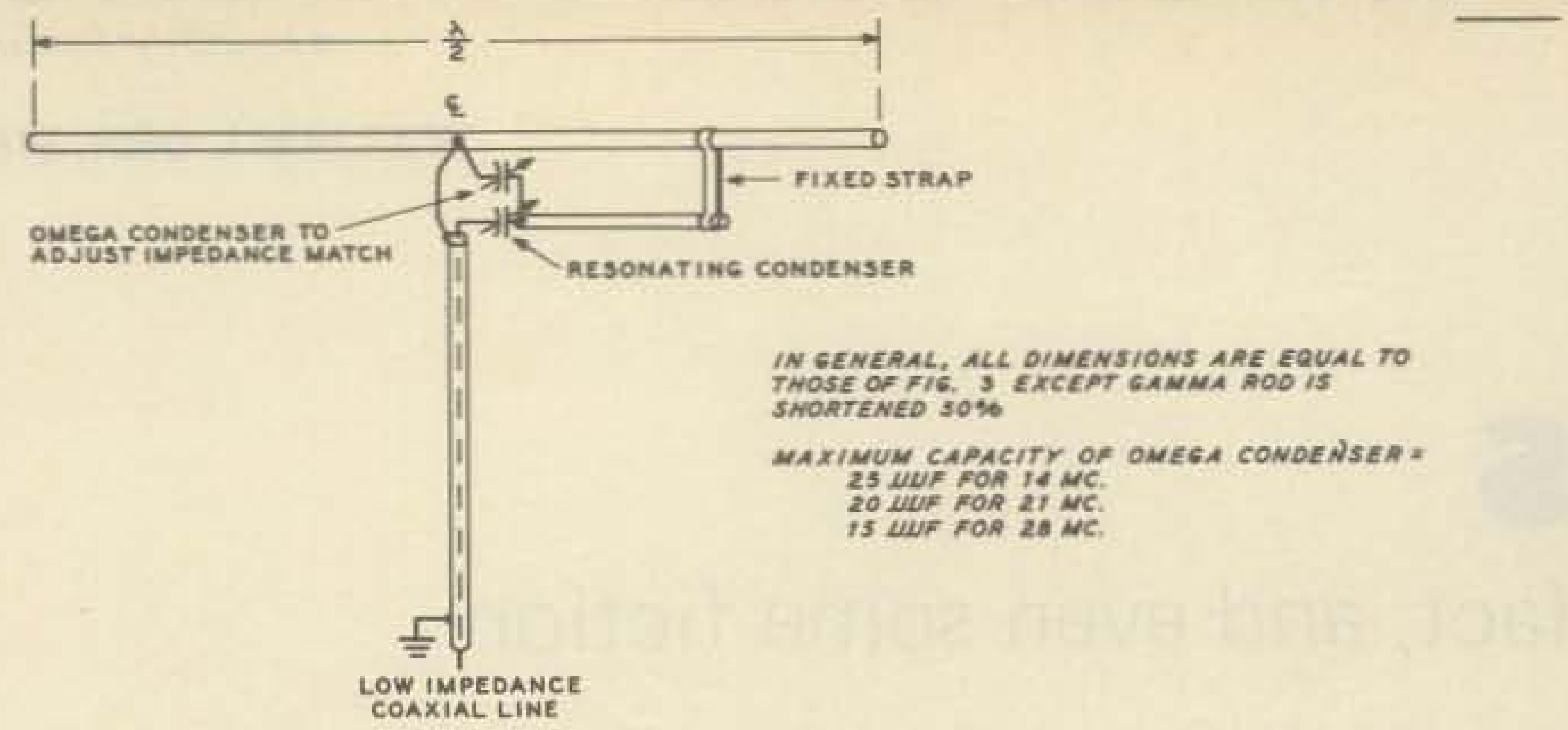


Fig. 4-The Omega match is an improved version of the Gamma match. The Omega capacitor allows a shorter gamma matching rod to be used and shorting strap does not require adjustment once approximate dimensions are set. The Omega match system was invented by W6SAI in 1955. (Drawing courtesy of Radio Publications, Inc.).

by means of the two variable capacitors to provide a very low value of s.w.r. on the transmission line."

"Sounds good," agreed Doc Liv. "Are there any shortcomings to this matching system?"

"Not really," I replied. "One vexing problem is waterproofing the variable capacitors. Some amateurs place them in plastic cups...some place them in waterproof metal boxes. Larry, KA9ACN, has a different approach to the problem. A close-up of his Omega match is shown in fig. 4. Larry made this model up to illustrate how his device goes together.

"This is a full-size model. The match is attached to a short section of dummy boom and a short dummy element. This shows how the matching system, boom and driven element are assembled.

"The Gamma rod is atop the element, running parallel with it. The Gamma capacitor is coaxial with, and inside, the rod. Heat-shrink tubing is used for the dielectric of the capacitor. The inner conductor of the capacitor is a short length of solid aluminum tube that can easily be slid in and out of the Gamma rod.

"The Omega capacitor, much shorter that the Gamma capacitor, is made in the same manner and can be seen between the Gamma rod and the driven element. The center conductor is grounded to the aluminum plate that serves as a mount for the coaxial receptacle and the Gamma rod, which, by the way, is insulated from the aluminum plate.

"Larry has a computer program which provides all the dimensions and settings for the Omega match system and this is a convenient point to use to zero-in on final adjustments."

A smile broke out on Doc Liv's face. "This is an elegant solution and I like it," he said.

I agreed, and added, "I would imagine that any readers of this column who desire more information can contact Larry directly. His address is 833 Cornelia St., Janesville, WI 53545. Or, quite possibly, he can be caught on the air."

"I hope to work him," said Doc Liv. "I'm sure he'd get a bang out of hearing his Omega match on the air."

"And I have something interesting for you in exchange," I remarked. "I finally got my hands on one of the new s.w.r.-power meters made by *Daiwa Corporation* in Japan. They are sold by the *J.W. Miller division of Bell Industries.* This is one nifty device (fig. 5)."

"Basically, it consists of two s.w.r. indicating devices in one box, connected back-to-back. A dual-pointer meter is used to provide instantaneous readings of forward power, reverse power and s.w.r. It has a readout in both watts and s.w.r. Once you use it, you'll not want to go back to the primitive models of s.w.r. meters that are floating around.

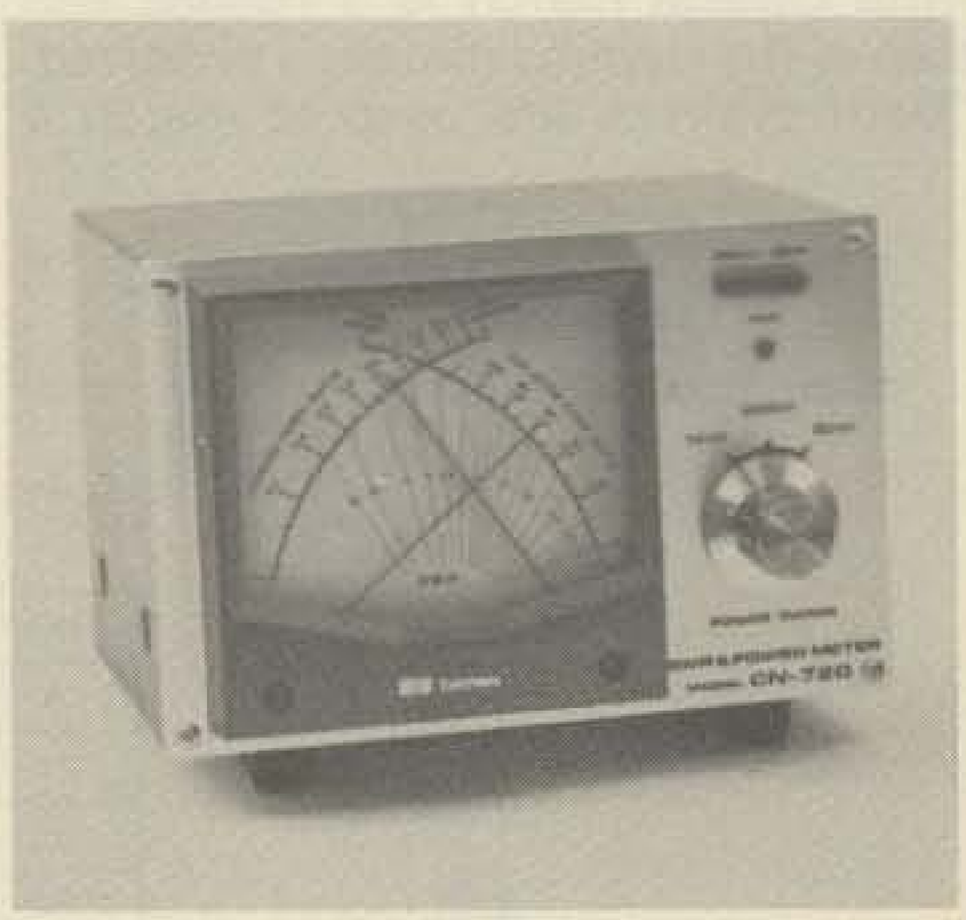


Fig. 5-The Daiwa Model CN-720 dual s.w.r. and power meter. A dual pointer meter provides instantaneous readings of forward and reverse power. The point the meter pointers intersect shows s.w.r. on a third scale. Meter operates at power levels up to one kilowatt.

"The unit provides three power scales of 1000 watts, 200 watts and 20 watts forward power. Reflected power scales are 200 watts, 40 watts and 4 watts. The forward and reflected power scales are selected automatically when you rotate the "Power Range" switch, and readout in terms of power and s.w.r. is automatic.

"It is possible to make s.w.r. readings across an amateur band and get both power and s.w.r. readouts directly from the dual meter. Not only does this give you a complete s.w.r. picture, but it also tells you what happens to power output at various frequencies and s.w.r. values. Some of the modern all solid-state rigs, you know, don't like to work into high values of s.w.r. and incorporate protection circuits that reduce power output as s.w.r. increases. This combination s.w.r. and power meter quickly shows up this action."

"Very interesting," remarked Doctor Liv as he studied the instruction manual. "This provides a 'three dimensional' picture of what is transpiring in the antenna circuit. Too bad the instrument belongs to you instead of to me!"

"I'll be pleased to loan it to you any time," I replied.

"Before we wrap this up, I know you'll be interested in a note I received from Lenny, W3GRF. I ran a picture of his 20 meter beam in a recent column and he gives me a run-down on the rest of his antenna farm. Listen to this: 'In addition to the big 40 meter beam, I have a 70 foot tower which holds three beams on a single boom 36 feet long. The array consists of two elements on 20, three on 15 and 5 on 10, all close-spaced for their individual band. There are no reflectors as such, only driven elements and directors.

'I also have two other 20 meter antennas, one a 5 element Yagi on a 48 foot boom at 100 feet height and another which is 7 elements on a 78 foot boom at 145 feet height. The fifth and last tower is 125 feet high and has a 6 element 15 meter beam on it.

'For 80 meters I use sloper antennas, a phased set on Europe and another phased set on a south-east heading. In addition, there are individual slopers for north-west and south-west headings. All the slopers have reflectors.

'Between the 125 foot tower and the 145 foot tower is the W3GRF antenna for 160 meters which is a 'T' with a 70 foot flat-top and the vertical portion the same. It has four radials at the base and is the best antenna I have used for the top-band. On the same rope holding the 160 meter antenna is a 40 meter vertical with radials, which is not too good.

'Lastly, I have four 550 foot long Beverage antennas used for reception

on 160 and 80 meters. Except for the slopers, all antennas are fed with large coaxial line (RG-218/U) to keep losses down, as some runs are well over 300 feet long. All the Yagis use Gamma matches, by the way. So, you see, the W3GRF antenna farm is extensive, requires a lot of upkeep and is very enjoyable.'

Dovtor Liv gave a low whistle. "Sure wish I had an antenna farm like that. I think I'm lucky to have a tri-bander Yagi and a sloper for the low frequency bands."

"Agreed," I said. "But it's fun to be into antennas in a big way. It gives you something to shoot for."

I handed my friend a slim paper booklet. "This is a dissertation on the construction of a simple and inexpensive two element wire Quad antenna for 40 meter operation. The antenna was built by Tony DePrator, WA4JQS, who has been a frequent contributor to my column. For those amateurs interested in 40 meter DX, this antenna should be very interesting. The antenna is slung betweên two towers, or other supports, and is aimed in a fixed direction. Tony aimed his array north and south to begin with, to reduce interference from European broadcasting stations and to improve his signal in deep Asia.

"He started out using just a driven element which gave him a bidirectional pattern but soon added the reflector for extra gain. Tony has prepared a four page write-up on his antenna and if you send a self-addressed, stamped envelope, I'll bet that he'll send you all the information on the 40 meter wire Quad. His address is 205 Cherokee Trail, Somerset, KY 42501."

"Good show," murmured Doc Liv as he jotted the address down in his note book. "If the antenna works, I'll trade him a root canal job for the information."

"Before you go, you might be interested in the unusual 80 meter antenna at KB4DV. Johnny calls it a modified sloper (fig. 6). He claims it covers the range of 3.5 MHz to 4.0 MHz with very low s.w.r. It looks like a variation of the so-called "ZL Special" antenna.

"KB4DV says it shows some directivity away from the feed point. He adjusts the resonant frequency by changing the length of the lower legs, but says the dimensions are relatively noncritical."

"It looks like an easy antenna to get working," remarked the Doc, as he gathered up his material and prepared to leave. "The 80 meter band is jumping, and now is the time to get something up in the air for all of that good DX."

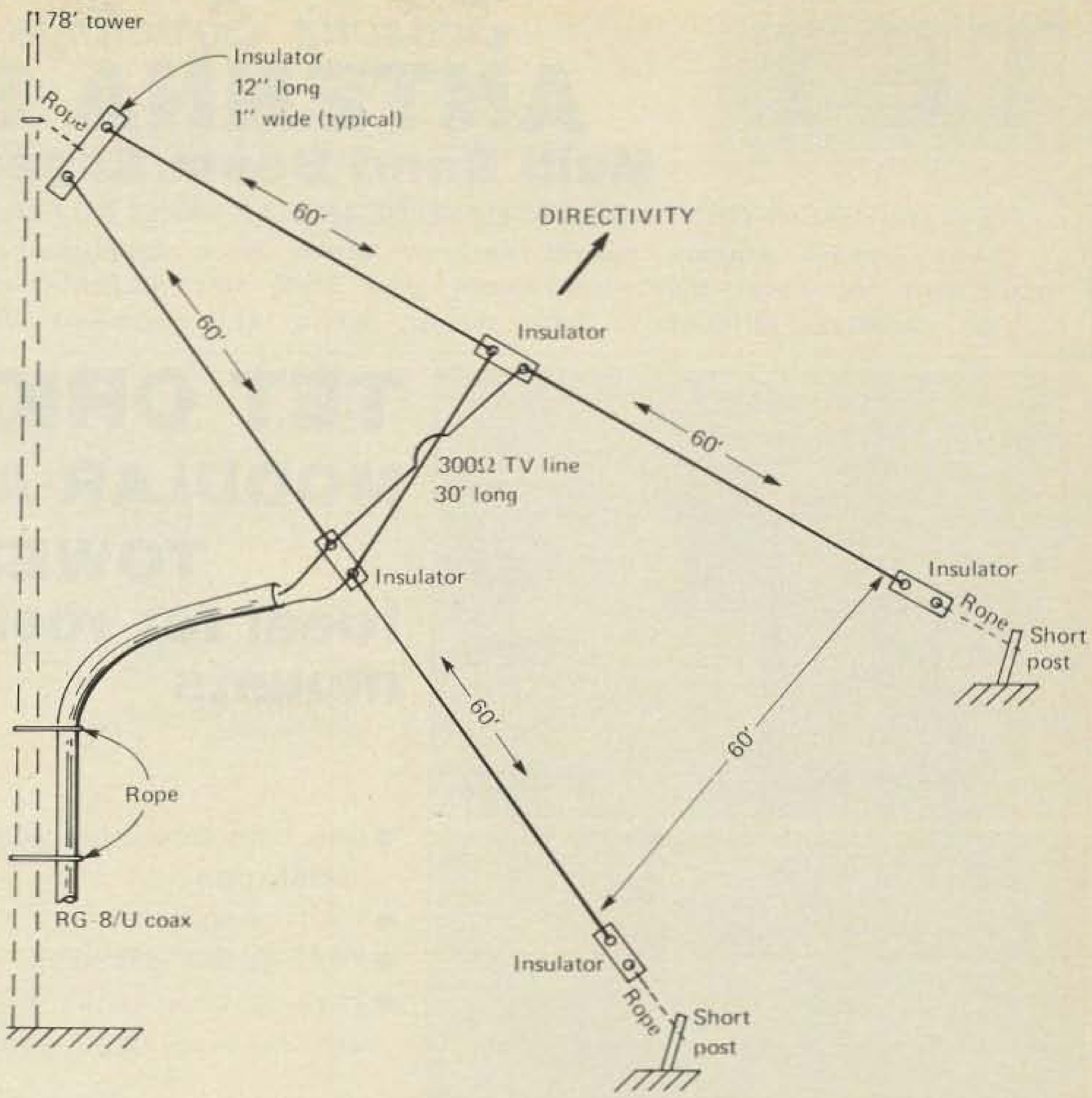


Fig. 6-The interesting 80 meter sloper antenna at KB4DV. It is a modified "ZL Special" hung from a single tower. Each leg of the antenna is about 120 feet long. The legs are fed at the center via a transposed length of 300 ohm TV ribbon line. The coaxial line is attached to the center of one leg. Antenna is hung from a 72 foot tower.

"Yes," I replied. "If you can't hear 'em, you can't work 'em."

Doctor Liv laughed. "You haven't been listening to the DX lists lately, have you?"

Note: Interested in inexpensive antennas that work? Read "Simple, Low-cost Wire Antennas for Radio Amateurs," by W6SAI. This 192 page handbook is published by Radio Publications, Inc., Box 149, Wilton, CT 06897. Price: $6.95 plus 75¢ for postage and handling.

a monthly feature by

WILLIAM I. ORR, W6SAI

Antennas

Design, construction, fact, and even some fiction

I couldn't believe my ears.

"Tell me again," I said as I sat down in the operating chair.

Doctor Livingston I. Presume smiled broadly as he sat down beside me. "I wouldn't put you on, would I?" he asked.

"Pendergast *married*? I can't believe it!"

Doc Liv was grinning from ear to ear. "He is. And you won't guess who he married. I would imagine all his old flames are in tears." The good Doctor leaned over and whispered in my ear.

"Well, I'll be darned," I said. "I didn't even know he was going with *her*. This is all very sudden."

My friend pulled a note out of his pocket. "Well, Pendergast remained a true ham to the last. He wants a schedule with you on 14,235 kHz each day on his honeymoon, starting tomorrow evening."

This was too much. "A true-blue ham," I shouted. "Taking a rig along on his honeymoon. Three cheers for Pendergast. I wonder what his bride will say finding a transceiver in bed with them?"

The good Doctor smiled. "All you have to do is wait until tomorrow evening and you'll find out."

I'll be there," I replied. "But I must admit your news has had a jarring effect. It's hard to come down to earth after that block-buster."

Doctor Liv agreed. But he thought that our mutual DX-friend would still have an avid interest in amateur radio in the years to come. He also thought that even if Pendergast dropped out of the ranks of active amateurs, sooner or later he'd be back on the air once again.

"They always come back," Doc Liv said firmly.

"Meanwhile, what about antennas?" I asked no one in particular.

"Here's a note in the mail from Tim, N4UM. He's had a lot of luck with multiple inverted-V antennas on 80 meters. The old bug-a-boo bandwidth is of great importance these days with the new sold-state transceivers. Many of them don't like to work into an antenna having an s.w.r. much in excess of 1.5-to-1. And they just turn themselves off! This is tough on 80 meters as it is very difficult to build a simple antenna that will maintain a low value of s.w.r. across the whole band. So most fellows cut their antennas for one end of the band or the other and let it go at that.

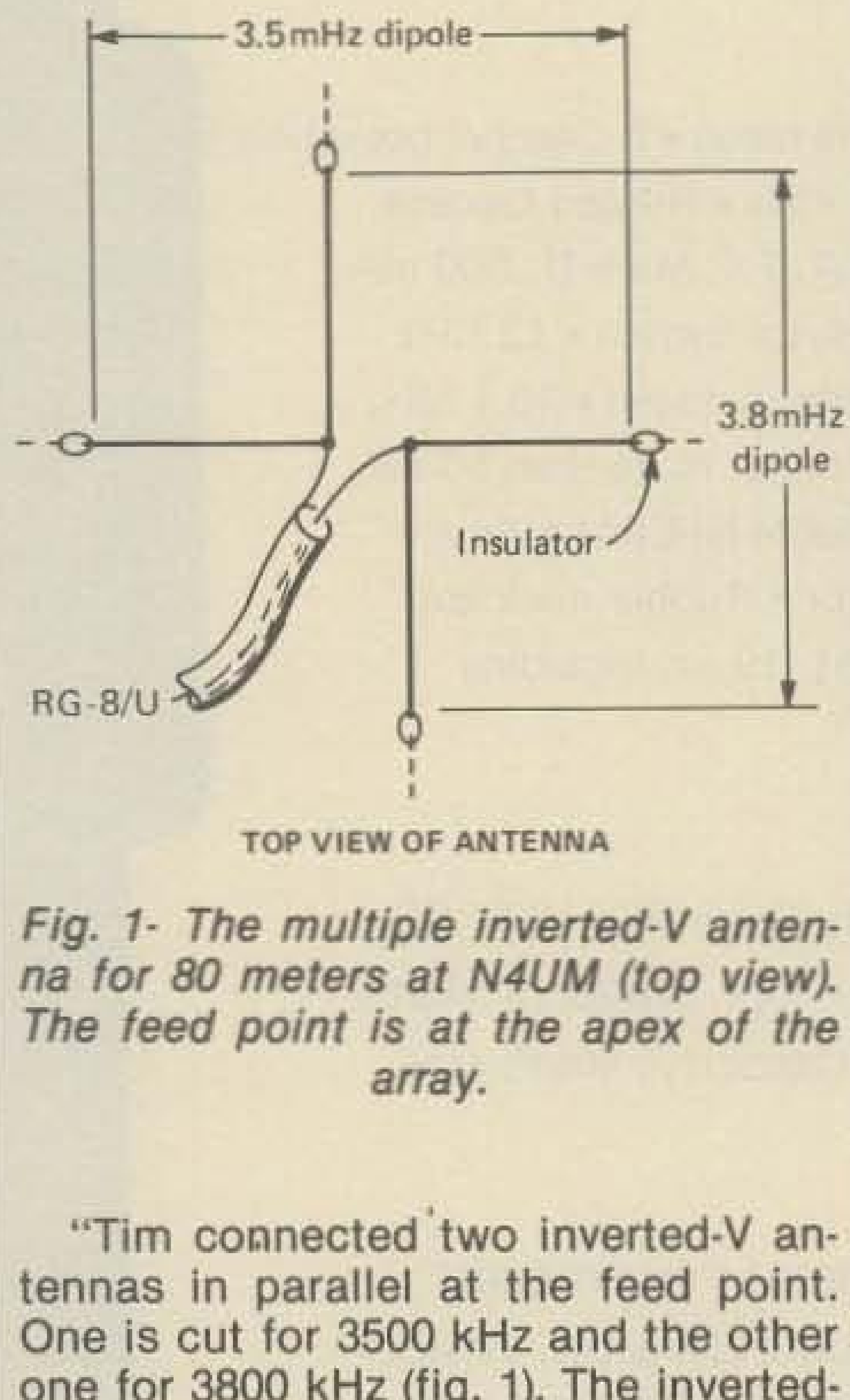


Fig. 1- The multiple inverted-V antenna for 80 meters at N4UM (top view). The feed point is at the apex of the array.

"Tim connected two inverted-V antennas in parallel at the feed point. One is cut for 3500 kHz and the other one for 3800 kHz (fig. 1). The inverted-V's are strung up at right angles from a single 70 foot tower. He cut the elements longer than called for by formula and pruned them back to the point where he wanted the lowest value of s.w.r. to fall. Results? Look at the s.w.r. curve of fig. 2.

"Tim says the antenna is virtually omnidirectional and the whole set-up was a lot cheaper than trying to "pull" a dipole from one end of the band to the other with an antenna tuner. And I agree.

"This is a simple antenna to get working and it should be a good one for this winter DX season on 80 meters."

I reached into the desk drawer and handed a thick manila envelope to Doc Liv. "Here's an interesting letter from Dick, WB6OHK, that might interest you. Most DXers know of his block-busting signal on 20 meters. He's been working on various antenna designs for television, f.m. and amateur radio since the early 'fifties'.

"In 1965 Dick designed a boomless Quad that would provide either horizontal or vertical polarization on 10 through 40 meters. It was a two element design and the Quad support arms were only 15 feet long each. The design functioned as a 40 meter dipole and as Quad on 20 meters and as an expanded Quad on 15 and 10 meters. The largest loop was 18 feet on a side and element spacing was 9 feet. The array was originally designed for broadband f.m. reception in the 88-108 MHz band.

"In 1978, after being off the air for a few years, Dick went to work on his original design and has come up with a 40 through 10 meter "Monster Quad" on a 35 foot boom (fig. 3). Basically, it is a six element Quad on 10 and 15 meters, a two element Quad on 20

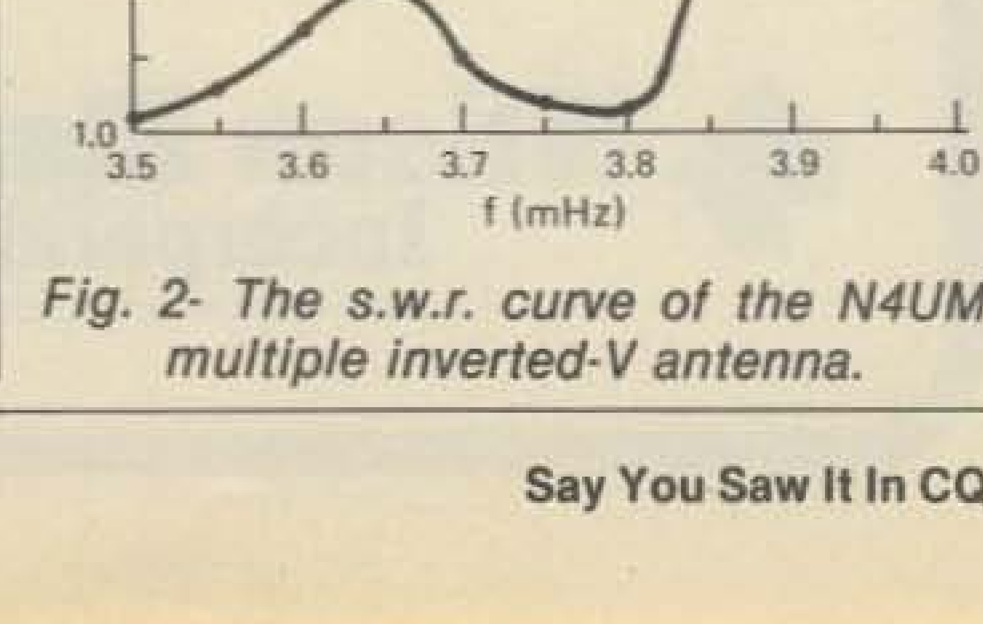


Fig. 2- The s.w.r. curve of the N4UM multiple inverted-V antenna.

48 Campbell Ln., Menlo Park, CA 94025

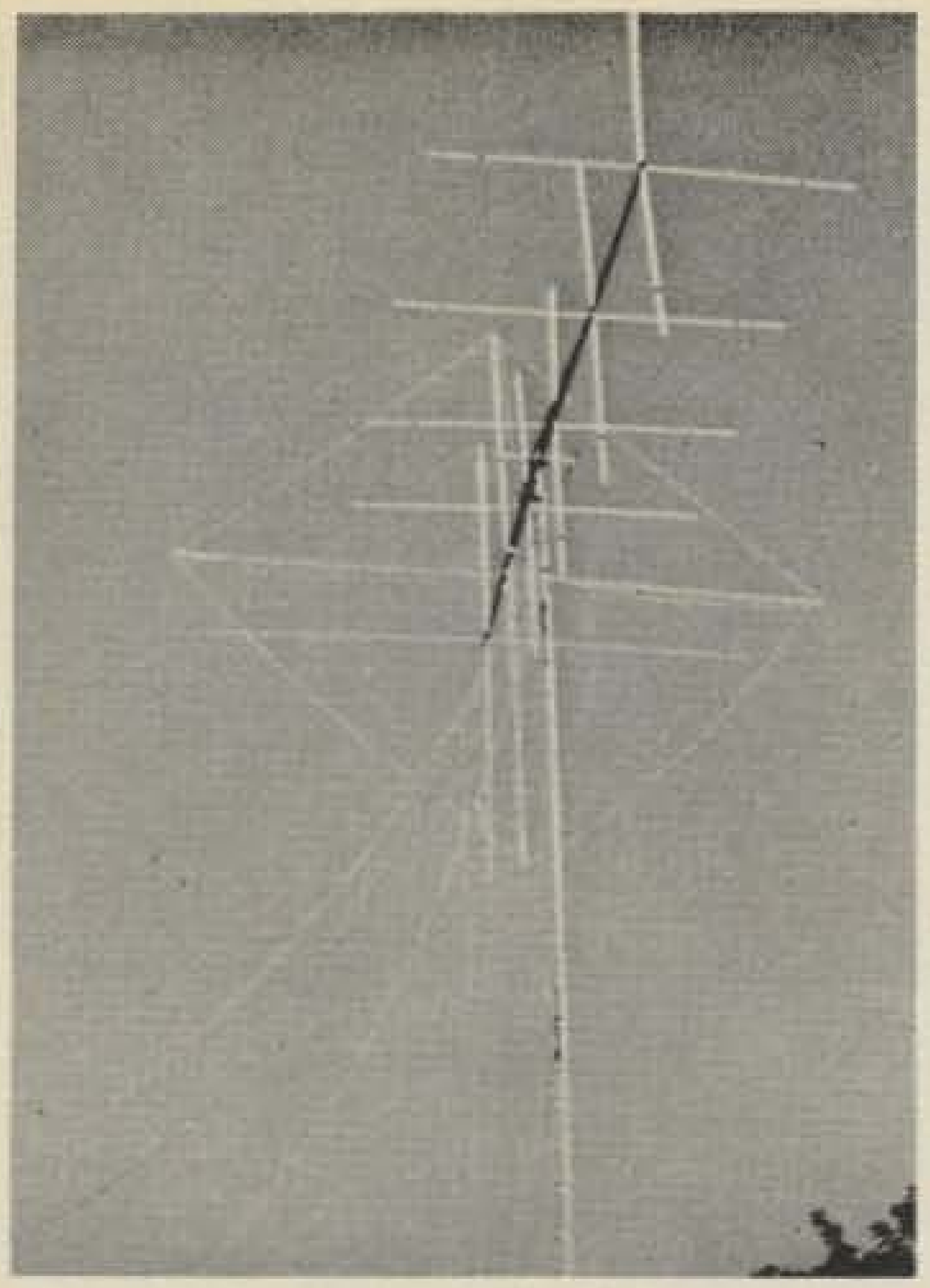


Fig. 3- The multi-band "Monster Quad" at WB6OHK. See text for details.

meters and a compact dipole on 40 meters. The biggest element—the driven element—is only 20 feet on a side and it's spreaders are 15 feet long. The whole array weighs about 65 pounds.

"The antenna is fed with RG-8/U coax line and an antenna tuner at the shack. This particular version is designed for horizontal polarization and the driven element is shown in fig. 4. It might be considered a fan dipole with the ends folded in, clockwise.

"A side view of the WB6OHK four band array is shown in fig. 5. The reflector has 20, 15 and 10 meter elements made of aluminum wire, which is also used on the driven element. The four 10 and 15 meter directors use #20 copper wire elements.

"Note that aluminum spreaders are used on the driven element. These are not broken up, and serve to act as reactance which cancels the radiation from the X-portion of the driven element. You'll note that the spreader length is just about a quarter-wave on 20 meters. On 15 and 10 meters there is little or no cancellation and the inner portion of the Quad loop radiates, providing some additional signal gain.

"The reason an antenna tuner is required is that the big loop is voltage-fed on 20 and 10 meters and current-fed on 40 and 15 meters. Loop Q is low and the s.w.r. on the coaxial line is not extreme, but a tuner is required at the bottom end of the line to provide a nonreactive match to the transmitter."

"Very interesting," said the Doc. "It looks as if this is an excellent antenna to play around with. Not many antennas that cover four bands and provide good gain on three of them!"

"Yes," I replied. "But not all amateur antennas are this complex. Many fellows are severely limited in antenna choice. Take Bill, AA4M, for example. He wanted a good, "invisible" antenna for 40 and 80 meter operation. His only chance was to erect something in a tall tree in his backyard. So he had a tree servicing company hang a pulley on a branch of the tree, about 70 feet up in the air. He then hung a length of #12 stranded, insulated wire secured to a nylon rope at the top.

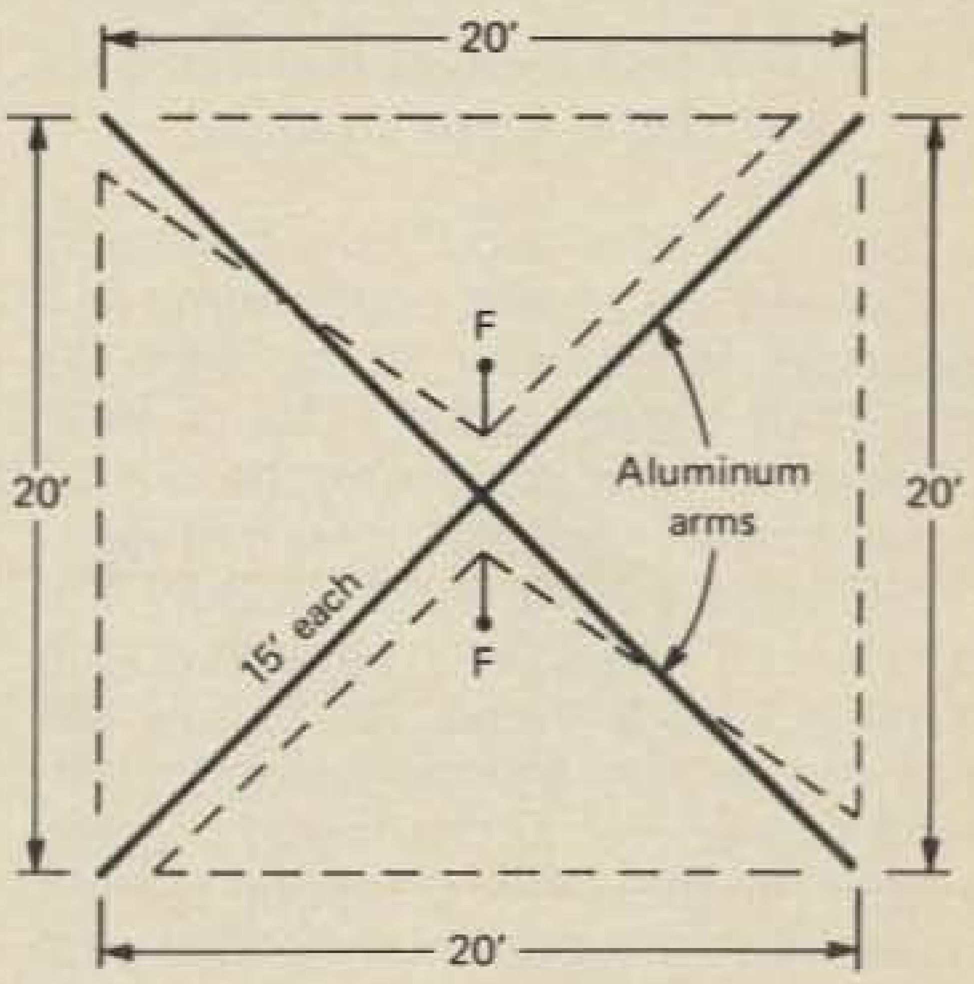


Fig. 4- The driven element of the WB6OHK Quad. The dashed lines indicate the wire element. F-F is the feedpoint.

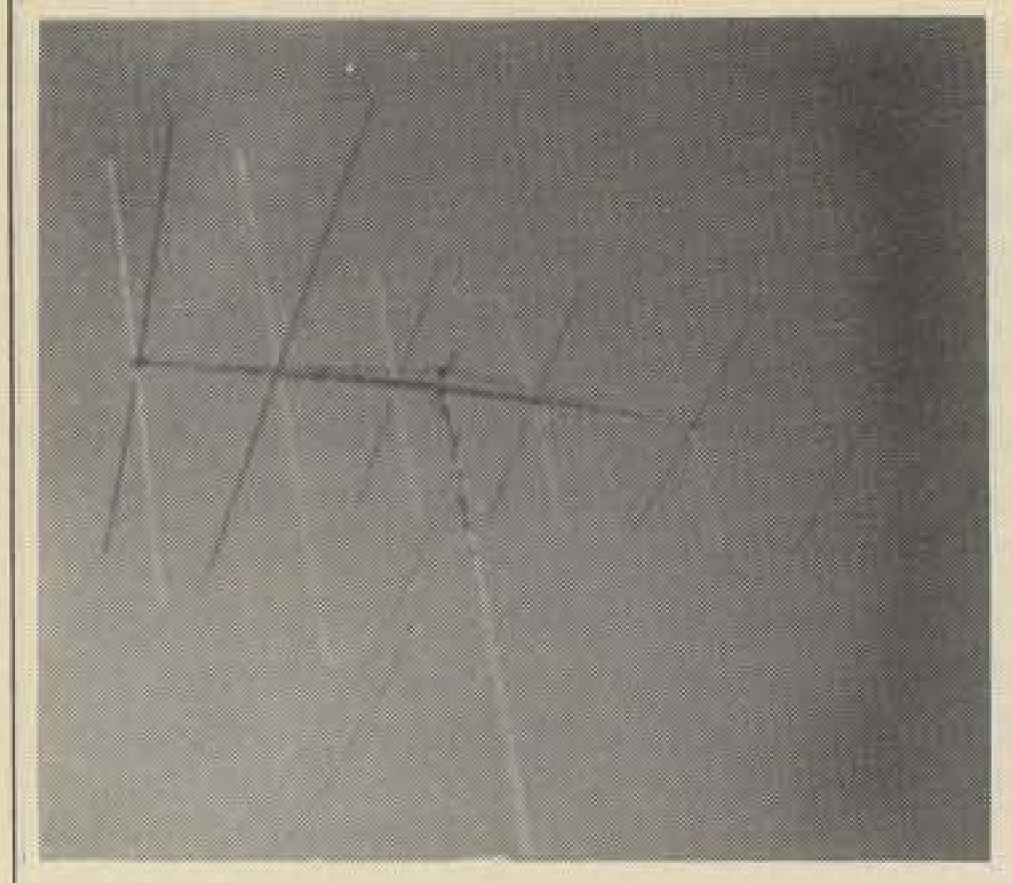


Fig. 5- The side view of the WB6OHK multi-band Quad antenna.

"Bill wanted a good ground system for his vertical so he bought some #17 electrical fence wire from Sears at less than eleven dollars for a half-mile! Over a period of time he put 16 radials down, each about 65 feet long.

"He tried several ways to bury the radials and finally evolved a workable scheme with a friend. A shallow slit was cut in the ground using a flat-head turf shovel and a friend put the wire in the ground and tapped the slit closed with a rubber mallet. Two people can put down 16 radials this way in about three hours.

"The only damage to the lawn was yellowed grass along the slits, but this turned green again in about 10 days."

Doctor Liv looked at a photo of the installation (fig. 6) which showed the base of the antenna (surrounded by a neat wire fence) and the cement counterweight block on the nylon rope which kept tension on the antenna. "Very nice," he pronounced.

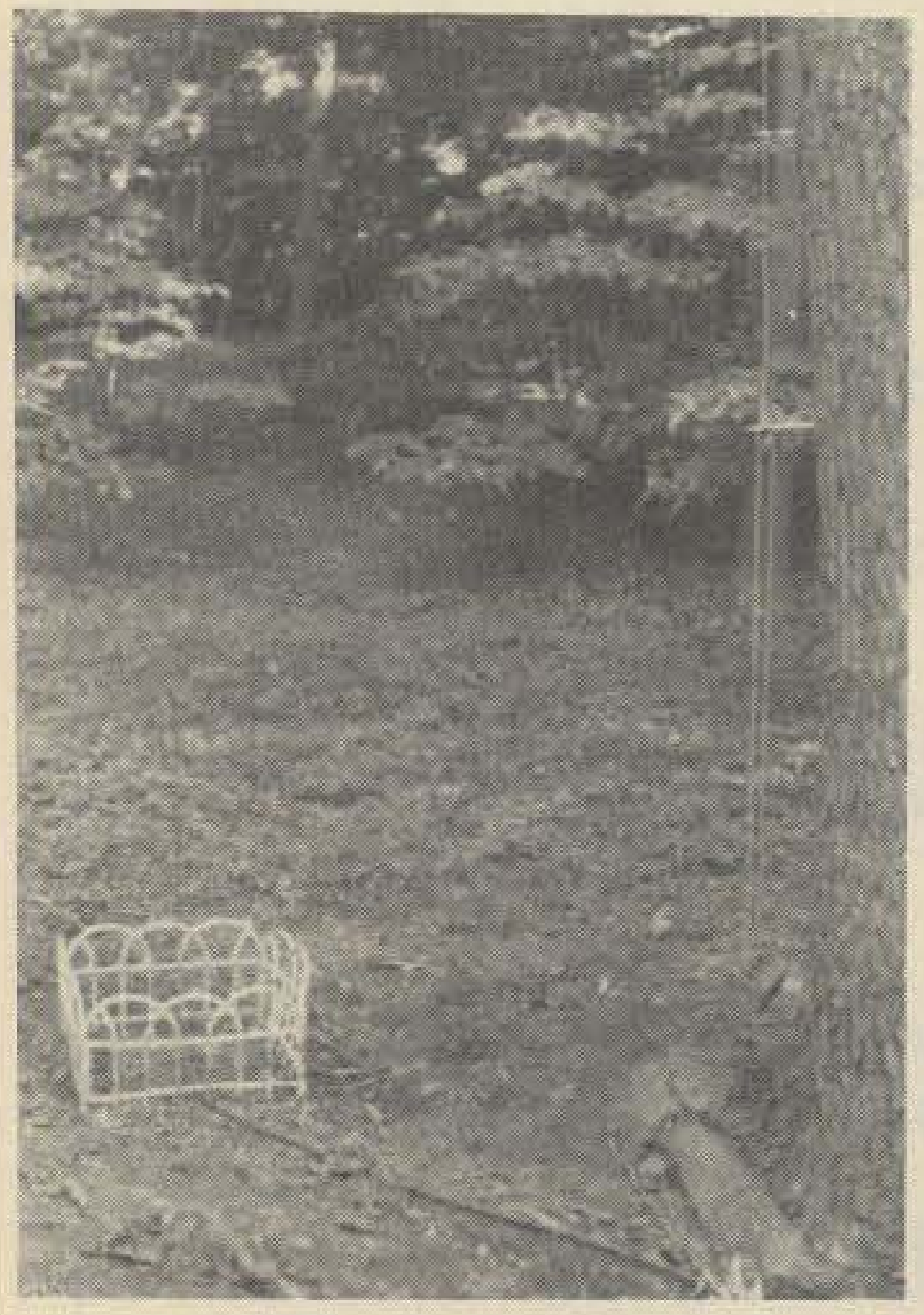


Fig. 6- The base view of AA4M's vertical antenna showing the counterweight (right) and the feedpoint.

"Bill says the antenna really works on 80 meters. He points out his 5 band DXCC in one winter season, with a 579 report from HS1ABD in Thailand—a long, long way from Virginia. Just recently he added a *Unadilla* 40-meter trap. Antenna length was reduced to 55 feet to make up for the trap inductance. He pruned the antenna for resonance at 7.0 MHz and 3.5 MHz and was pleasantly surprised to see that he could cover the whole 40 meter band with a reasonable s.w.r. value and could work as high as 3.85 MHz on 80 meters without the s.w.r. getting out of hand.

"Bill sent me a picture of the antenna, but its nearly invisible, so no use showing it. As he says, its very difficult to take a picture of a nearly invisible antenna!"

"I've heard AA4M on 80 meters," said Doctor Liv. "He's one of the best signals in here from the east coast."

I tossed a short note over to my friend. "Remember Pendergast wouldn't tell us where he went on his honeymoon? But Paul, VE3KOI, knows."

Doc Liv raised his eyebrows. "How did he find out Pendergast's little secret?" he asked.

"Very simply," I replied. "Look at this map that Paul sent me. It shows a section of Scott Passage, on the northern reaches of Lake Huron. Just off the Canadian coast, near Algoma, is Pendergast Island at 82°43' West latitude and 46°10' North longitude. Deduction tells us that is where our friend and his new bride are spending their honeymoon!"

The two friends continued in easy conversation as the day waned and evening came on. A cold bottle of California Chablis sat on the table and the setting sun made the glasses glow with a robust color. In the background an observer could note the station receiver running at low volume. Radio conditions were excellent and DX from all over the world was pouring in. But there was no hurry. Tomorrow would be another day.

a monthly feature by

KARL T. THURBER, JR., W8FX

Antennas

Design, construction, fact, and even some fiction

Last month we introduced this antenna column with some of the new editor's philosophy and kicked things off by providing some important, fundamental antenna and transmission line concepts. Author W8FX expands last month's basic antenna glossary with more terms in this issue.

Last month we kicked off this column under new editorship by "setting a baseline" with some of the more important antenna and transmission line terms and concepts. Again at the risk of offending our more advanced brethern, I would like to begin by expanding our set of terms to include a few dozen more that are important to acquiring a broadbased knowledge of antenna design, construction and use.

Let's add the following to last month's glossary.

* * *

Ammeter, R F — Current-sensitive device that responds to radio-frequency (r.f.) energy flowing through a transmission line.

Antenna pattern — Graphic depiction of antenna's magnitude of radiation, stated in terms of direction and distance from the antenna. Paper representation may be called a polar plot.

Attenuate — To reduce in power or strength. An electrical device that performs this function is known as an attenuator.

Bandpass filter — A selectivity-enhancing device that allows only a certain frequency range to pass through unattenuated.

Bandwidth — The range of frequencies over which an electrical circuit or antenna will work efficiently. Also refers to the upper and lower limits of a band of frequencies.

Beamwidth — Angular distance between the directions at which received or transmitted power is one-half the maximum power.

Broadside array — A driven antenna array usually consisting of two parallel elements lying in the same plane.

Capacitive reactance — Resistance offered by a capacitor to the flow of alternating current, as measured in ohms. Stated as X_C.

Characteristic impedance — The "apparent" resistance or impedance of a transmission line. Commonly represented by the symbol Z_0. See surge impedance.

Coaxial antenna — An antenna that uses coaxial cable or construction for all or part of its length. Usually vertically polarized.

Collinear array — A gain-type, directive antenna operated with its elements in phase to produce maximum radiation at right angles to the line of the antenna. A one-wavelength dipole could function as a collinear array operated as two half-waves in phases.

Collinear antenna — (v.h.f.) — Long, phased vertical whip antenna designed to produce a low angle of radiation and substantial power gain over a quarter-wavelength antenna. Usually consists of 1/4- and 5/8-wave radiating sections.

Decoupling coil — An inductance that electrically isolates one electrical circuit or device from another.

Delta match — A method of matching a low-impedance antenna such as a dipole, to higher-impedance parallel-conductor (open-wire) transmission line. The open-wire line is fanned out as it approaches the antenna element in accordance with predetermined dimensions.

Discone antenna — Very broadbanded antenna, vertically polarized and conical in shape, normally used at v.h.f. and u.h.f. frequencies. Very popular as a v.h.f./u.h.f. monitor antenna.

Driven array — An antenna in which all of the elements are driven (directly excited) elements.

Dummy load-wattmeter — Combination instrument that contains a power-absorbing device, used in lieu of an antenna, and a wattmeter to read a transmitter's output power. Primarily a servicing and test instrument.

Echelon antenna — A specialized, long parallel-wire antenna with the wires spaced one-half wavelength or more. The wires are staggered at their origins to form a parallelogram rather than a rectangle as is usual with other parallel-wire antennas.

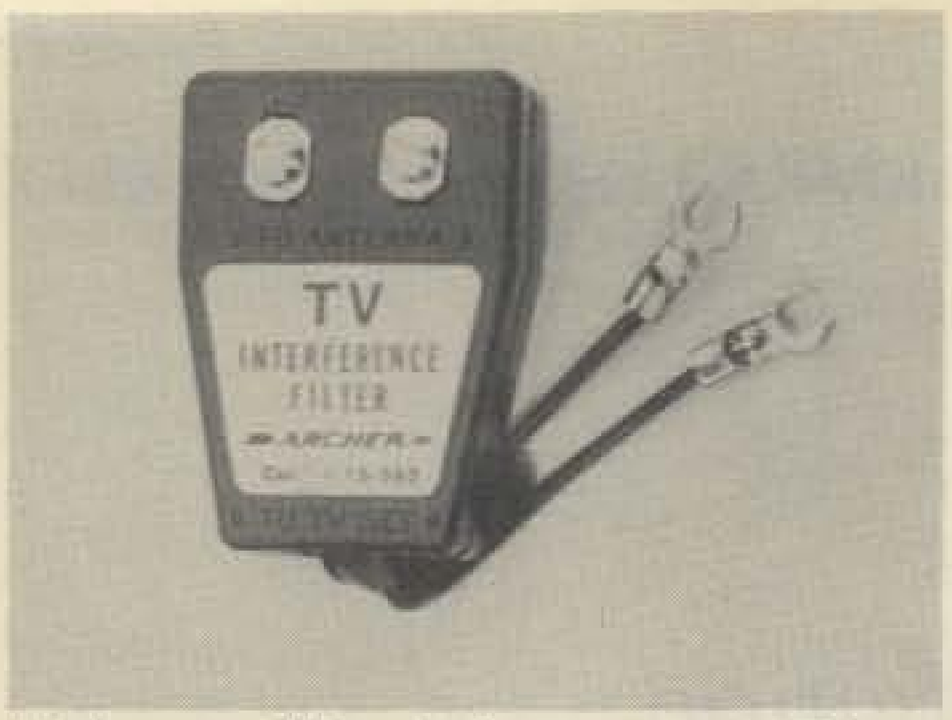
Electrical length — Equivalent length of an antenna wire or transmission line as determined by the velocity of propagation through it. Will not correspond with the line's physical length.

End-fire array — A broad class of antenna that consists of a number of parallel elements in one plane. Maximum radiation takes place along the array's axis, and it may be unidirectional (one-way) or bidirectional (two-way).

Extended double Zepp — An antenna consisting of two collinear elements

Dummy load-wattmeter is a dual-purpose instrument that assists in servicing and tuneup. Unit shown here works over the frequency range of 2-230 MHz and handles up to 1000 watts r.f. power. (Photo courtesy Barker & Williamson)

631 N. Overbrook Drive, Ft. Walton Beach, FL 32548



Highpass filter helps prevent TV set fundamental overload by amateur and other signals below its cutoff frequency. (Photo courtesy Radio Shack)

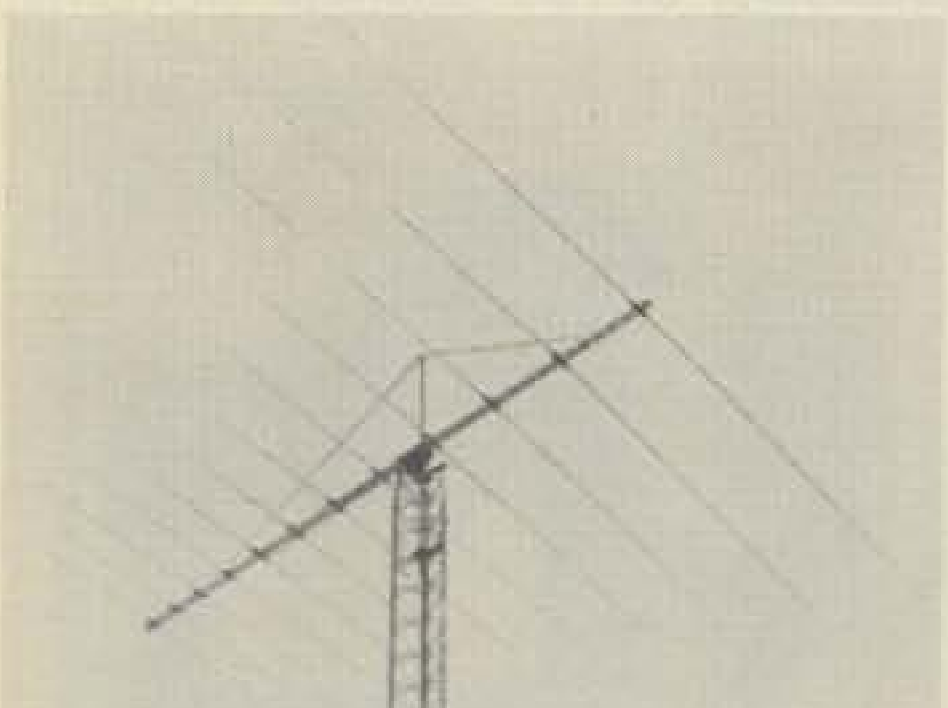
slightly longer than one-half wavelength—typically 0.64 wavelength. This antenna effectively gives more gain than its cousin, the 2 elements-in-phase collinear.

Feed impedance — Impedance, expressed in ohms, at the point at which an antenna is connected to the transmission line. Sometimes referred to as input impedance, especially as applied to the effective impedance existing at the end of a transmission line.

Flattop — Slang for a wire antenna, such as a dipole or single-wire.

Flat lines — Untuned lines, such as coaxial cables, that act strictly as transmission lines. In truly flat lines, line length does not affect the input impedance the transmitter "sees."

Folded dipole — A two-wire dipole-type antenna that has a higher feed impedance than a standard dipole. Folded dipoles are frequently used to obtain a good match to 300 ohm twin-lead transmission line. Their construction allows slightly increased bandwidth over that of a simple dipole.



The log-periodic antenna is a high-gain, usually large rotatable multiple-element beam antenna that is designed to yield consistent performance over a very wide operating range. This giant, 335 lb. Hy-Gain antenna is designed for continuous coverage across 13 to 30 MHz with a 13.5 dB average gain figure, as referenced against a standard dipole antenna. Its surface area of more than 17 sq. feet dwarfs most Quads—and the same firm sells an even larger 40- through 10-meter version that weighs in at 635 lbs. and sports a 37 ft. boom! (Photo courtesy Hy-Gain Electronics)

Halo antenna — A horizontal dipole bent into a circle. Used to attain horizontal polarization in mobile work.

Highpass filter — A circuit that rejects frequencies below a given cutoff frequency. Often used on TV receivers to reduce or eliminate TVI (television interference) from amateur h.f. transmitters.

Impedance matching — Process of adjusting ("matching") impedance so that maximum power flows through a circuit. As applied to antennas and transmission lines, minimum s.w.r. will also exist.

Inductive reactance — Resistance offered by an inductor to the flow of alternating current, measured in ohms. Stated as X_L.

"J" antenna — Consists of a half-wavelength vertical radiating element fed by a quarter-wave matching section. Often used in mobile work as it offers some gain over the usual quarter-wavelength whip.

Lazy H antenna — A four-element broadside antenna array, normally consisting of four, half-wavelength elements spaced one-half wavelength, in the form of the letter "H."

Log-periodic antenna — High-gain, usually large multiple-element beam antenna that is designed to operate over a broad range of frequencies.

Longwire antenna — An antenna, usually consisting of a single wire, at least several wavelengths long. The longer the antenna, the greater the gain. (This type of antenna is frequently confused with the single-wire. A single-wire antenna isn't a "longwire" unless it is, in fact, *long* in terms of the operating wavelength).

Loop — A "closed circuit" type of antenna, in which a conductor is formed into turns so that the ends are close together. Most loops are highly directional, and are therefore popular in certain receiving and direction-finding applications.

Lowpass filter — A circuit that rejects frequencies above a given frequency. Can be installed in an amateur transmitter's transmission line to reduce TVI-producing harmonic output.

Matching sections and stubs — Short transmission line lengths that are specially selected as to length for insertion into or connection to an antenna system to alter its impedance characteristics.

Multiband antenna — A wide-range antenna that can be made to receive and transmit satisfactorily over more than one band. In all cases, a design compromise or compromises must be made to enable multiband operation.

Multiple-dipole antenna — A system consisting of several center-fed, half-wavelength dipoles connected in parallel at the location where the transmission line is connected. Each dipole is "cut" for a specific band for optimum performance.

Parallel-wire line — R.f. transmission line consisting of two parallel conductors. Sometimes called open-wire line. TV-type twin-lead is a form of parallel-wire line.

Phase — In an a.c. circuit, the relationship between voltage and current.

Pi-network — Transmitter output ("tank") circuit or antenna coupler design, capable of handling a wide range of antenna system impedances. Consists of an inductor (coil) and two capacitors.

Lowpass filter attenuates h.f. signal harmonics that, if radiated, could interfere with local television reception. B&W unit shown here handles 100 watts r.f. and has a cutoff at 30 MHz. (Photo courtesy Barker and Williamson)

Plumber's delight — Slang term for a large heavy-duty all-metal parasitic beam antenna.

Prune — To adjust or shorten the length of an antenna to make it resonant at the desired frequency.

Random-wire antenna — An antenna, usually of single-wire construction, of any convenient length driven directly by a transmitter's or antenna coupler's output circuit. Not a "longwire" antenna unless physically long with respect to wavelength.

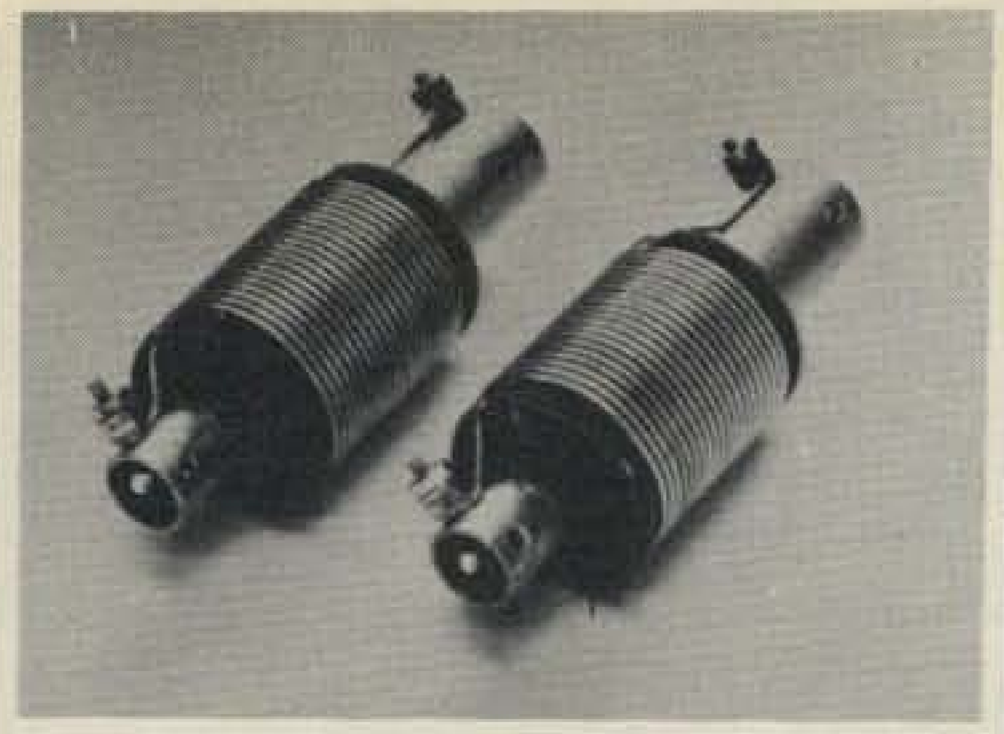
Reflected power — Power "returned" in a transmission line under mismatch conditions. In extreme cases, when the load resistance is either zero or infinity, all power is reflected back.

Reflectometer — A s.w.r. (standing wave ratio) indicator.

Resonator — An loading coil, used to make a physically short antenna of the proper electrical length for use at a given operating frequency.

Rhombic antenna — Resonant or nonresonant longwire antenna, usually diamond-shaped, in which all legs of the antenna are the same length. High directivity and effective gain figures are possible.

Single-wire antenna — Direct-fed wire



Example of Reyco dipole antenna traps to enable multiband operation with a single flattop. Addition of such traps allows low s.w.r. performance on 2 to 6 bands, depending on how many trap pairs are installed. Resultant antenna is fed with standard coaxial cable (50-75 ohm). (Photo courtesy Unadilla/Reyco)

Type Antenna	dB gain over half-wave dipole	dB gain over isotropic source
Isotropic radiator	- 2.1	-N/A
Ground plane vertical (¼-wave)	- 1.8	+ 0.3
½-wave dipole	-N/A	+ 2.1
5/8-wave vertical	+ 1.6	+ 3.7
.64-wave vertical	+ 2.2	+ 4.3
VHF Collinear mobile antenna	+ 3.4	+ 5.5
2-el Yagi	+ 5.0	+ 7.1
Phased VHF 5/8-¼-5/8 wave vertical	+ 6.0	+ 8.1
Phased VHF 5/8-5/8-5/8 wave vertical	+ 7.0	+ 9.1
2-el Quad	+ 7.0	+ 9.1
3-el Yagi	+ 8.0	+ 10.1
4-el Yagi	+ 10.0	+ 12.1
5-el VHF Yagi	+ 9.6	+ 11.7
3-el Quad	+ 10.0	+ 12.1
4-el Quad	+ 12.0	+ 14.1
Rhombic (5-wavelength legs)	+ 12.0	+ 14.1
Log periodic	+ 10 to + 14	+ 12.1 to + 16.1
10-el VHF Yagi	+ 12.0	+ 14.1
44-el VHF Quad array	+ 17.1	+ 19.3

Note: Gain figures are "typical." Expect to see slightly different figures quoted by different manufacturers and in various texts. Element configurations and spacing will also play a part.

Table I - Selected antenna gain figures.

antenna, in which the "return circuit" for the line is the earth. In effect, with this type of antenna, the transmission line and antenna are as one.

Skyhook — Slang for an antenna, especially a large, high wire antenna.

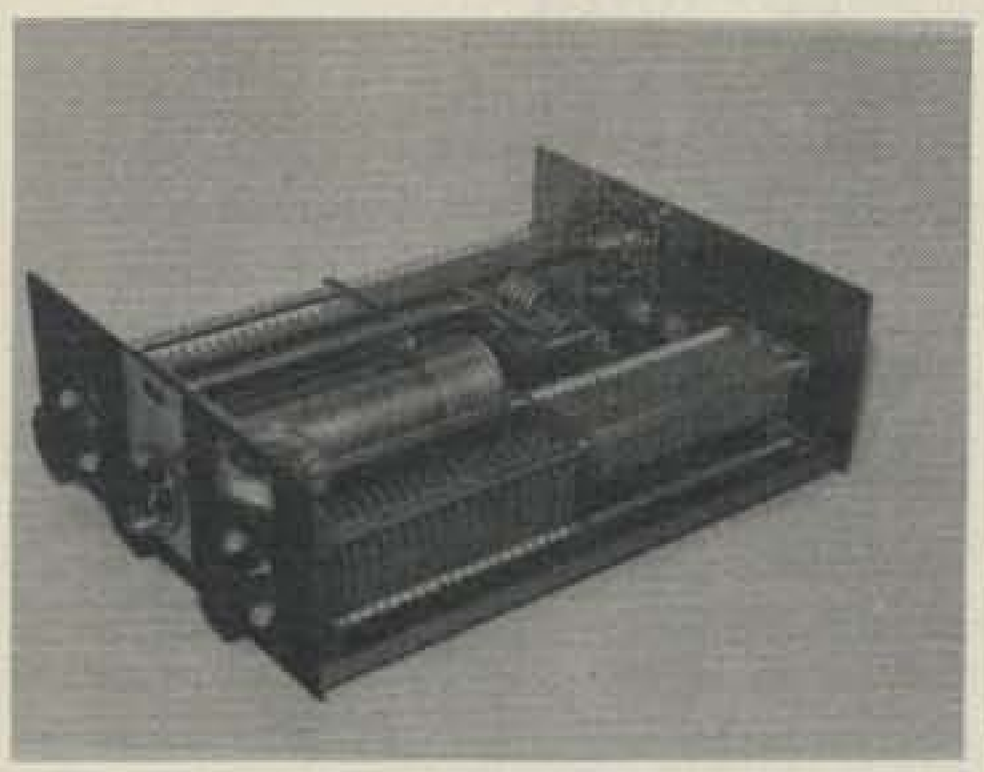
Sterba array — Large driven antenna system made up of both parallel and collinear elements.

Surge impedance — The characteristic impedance of a transmission line.

Trap antenna — Multiband antenna in which selected tuned circuits are placed in an antenna to effectively create resonances at several different operating frequencies. Commonly used in dipole, vertical, and beam antenna designs.

Turnstile antenna — Two dipoles placed at right angles to one another for the purpose of obtaining a near-omnidirectional radiation pattern.

Tuned (resonant) feeder — A transmission line that must be cut to a certain length to achieve a given input impedance for proper antenna system operation. Many multiband antennas fed with open-wire lines operate with resonant feeders.



Wide-range antenna coupler matching circuit enables various kinds of antennas to be "hitched" to the pi-network output tank which most current hamband transmitters use. Representative tuner, innards of which are shown here, handles parallel-wire, single-wire, and coax-fed antennas of various types. (Photo courtesy Murch Electronics)

"T"-match — A matching system, similar to the Gamma match, to impedance-match a dipole antenna element to parallel-wire transmission line.

Vee antenna — Describes various antennas (longwires and dipoles, etc.) that are bent into a V-shape either for changing the antenna's directivity characteristics or for convenience in sizing the antenna to real estate. A variation is the inverted-Vee, or "drooping dipole," mounted from a high center support with the ends suspended but a few feet above the ground.

Velocity factor — As applied to transmission lines, this is the ratio of the actual velocity along the line to the velocity in free space. As a result of velocity factor, the electrical length of a transmission line doesn't correspond with its physical length.

Windom — Early multiband, off-center-fed antenna. It is made up of a half-wavelength antenna cut for the lowest frequency band to be used, with a single-wire or parallel-wire feed line.

Zepp antenna — End-fed, resonant antenna named for the trailing wire antennas of the Zeppelins. Basic configuration is a half-wave dipole that is end-fed by a parallel-wire transmission line.

This wraps up our two-part glossary of antenna and transmission line terms. Next month, we will move on to cover new material especially with the beginner in mind.

73, Karl, W8FX

a monthly feature by
KARL T. THURBER, JR., W8FX

Antennas

DESIGN, CONSTRUCTION, FACT, AND EVEN SOME FICTION

In last month's column, we discussed the center-fed dipole, far and away the most popular antenna used on the h.f. bands. We pointed out that this antenna was simple to design and construct, and that it was also quite inexpensive. We also highlighted one of the most important features of the dipole: the fact that it works with a minimum of effort and adjustment being required.

To review, the dipole has two arms which are separated by a center insulator and connected to one another by the transmission line. Normally constructed of wire, the dipole is a resonant half-wavelength antenna. Its practical length is 5% less than one-half of the "free space" wavelength of the frequency for which it is designed. In the simple dipole, the wire is cut exactly in the middle and a transmission line is attached at the center point. We pointed out last month that the dipole can be operated efficiently and effectively at *odd harmonics* of the fundamental frequency, and that several dipoles can be joined together at the center and fed in parallel to allow operation on frequencies that are not necessarily harmonically related. We also mentioned that the *folded dipole* makes a good *broadbanded* antenna.

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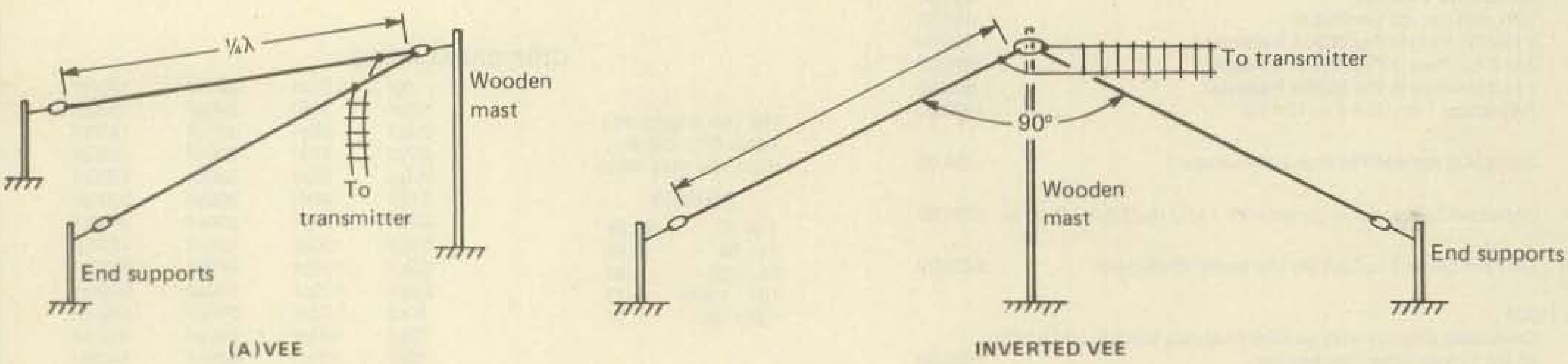
In this month's column, we will follow up with a discussion of some major dipole variations. We will cover Vees and inverted Vees, vertical dipoles, slopers, "T2FDs," double bazookas, double Zepps, and extended double Zepps. We'll limit ourselves to relatively simple center-fed antennas this time, saving fancier wire antennas such as the Windom and the trap dipole for a later column.

The Vee and inverted Vee. For convenience in fitting an antenna to a particular piece of real estate, or for sharpening up a dipole's radiation pattern, the dipole can be bent into the form of a horizontal "V". Doing this will cause the directional pattern of the antenna to become sharper in both the horizontal and vertical planes. Maximum radiation will be along the line bisecting the "V." Usually, the "V" or **Vee antenna**, as it is popularly known, is made quite long with respect to wavelength, to effectively make it act as a wire beam exhibiting several dB of gain over the simple dipole. For example, a Vee about 100′ on a leg (200′ total) fed with tuned feeders as a resonant antenna will show about 7 dB gain on 10 meters, 6 dB on 15, and 4 dB on 20. The radiation pattern will be as mentioned, though it will change slightly from band to band.

Closely related to the Vee is the **inverted Vee,** named for the fact that it is strung out in the form of a nearly upside-down letter "V". Sometimes known as **drooping doublet,** the antenna is supported by a single high mast or pole, with the ends made to slope down toward the ground. There are some definite advantages to this type of antenna: it requires but *one* main structure, not two; its radiation pattern is more-or-less omnidirectional, as opposed to the figure-eight pattern of the basic dipole; and it can be used for either single-band or multi-band operation, depending on its specific construction. It's also a space saver for small city and suburban lots.

The inverted Vee is a simple anten-



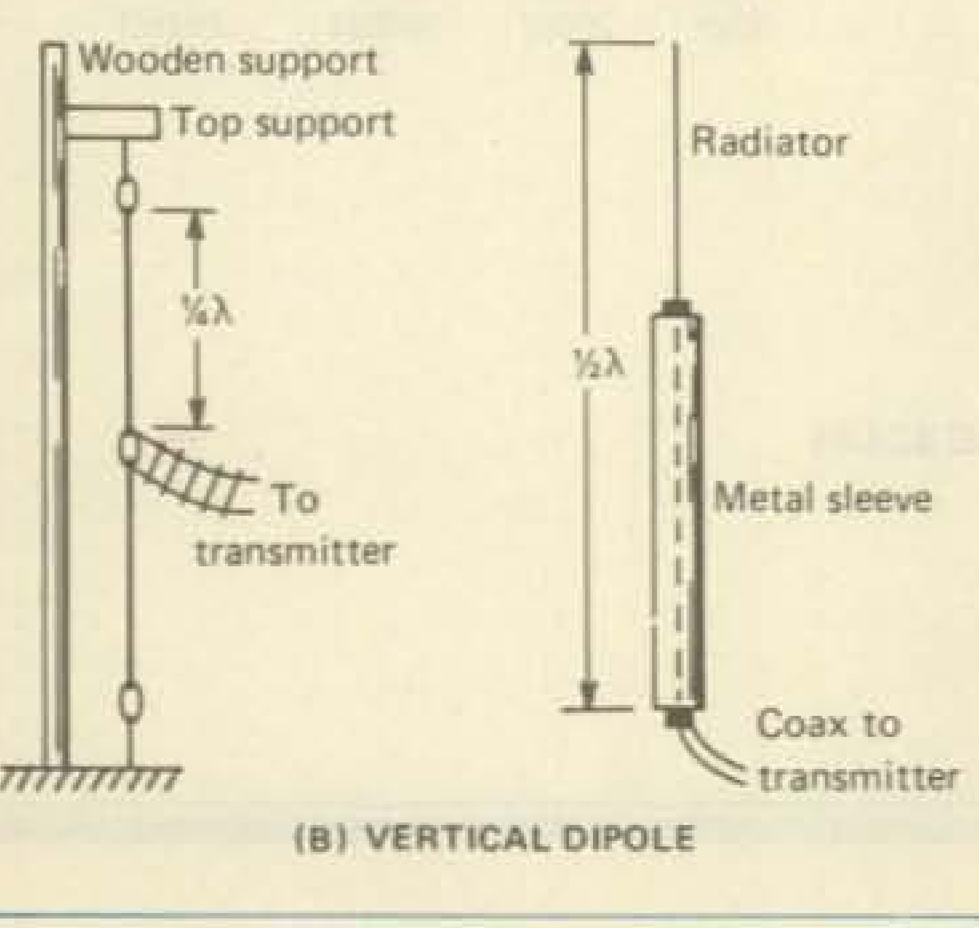
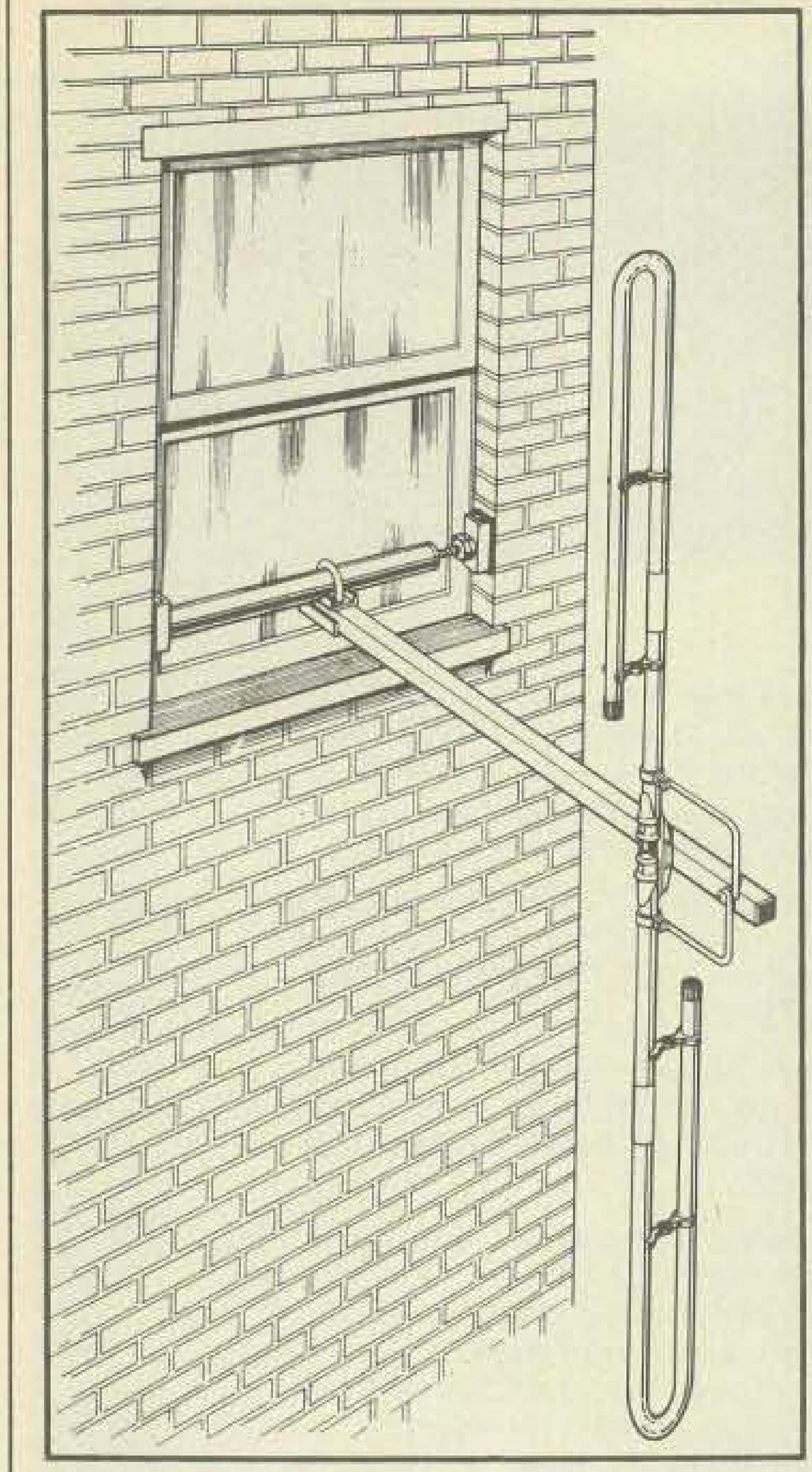


Fig. 1(A)-At left is the basic Vee, and at right, the inverted Vee. Each antenna can be fed either with coaxial cable or with open-wire line. If cut for ½-wavelength at the lowest band to be covered, each can function as a multiband "Vee beam" when fed with resonant (tuned) feeders.

(B)-At left is the basic vertical dipole, simply a dipole strung vertically rather than horizontally, and fed at the center. This kind of antenna eliminates the need for ground-plane radials, but the height required is usually excessive on the lower h.f. bands. The coaxial dipole, on the right, is a popular CB and 10-meter antenna. The whip-and-sleeve construction makes for a relatively simple and mechanically sturdy antenna that is attractive to the eye.



Although designed for CB use, this Finco Stinger W-40 window mount antenna is illustrative of what can be done to fit a vertical dipole to limited space. The dipole elements are bent back on themselves and fed with a Beta match to achieve good bandwidth across the entire CB range with an impedance at the center of 50 ohms. Radiator length is but 5.9 feet. Antennas of this type can easily be cut down for 10-meter use, and are particularly useful to the apartment dweller who cannot install an antenna on his building's roof. (Photo courtesy The Finney Company)

na to install and adjust. Best results are usually had when the apex angle at the "V" is between 90 and 120 degrees. A wooden support pole should be used to prevent pattern distortion, and the end supports should be at least 7′ high to prevent people from walking into the antenna. Bear in mind that its resonant frequency will be sensitive to apex angle, height, and end-effects, so tweaking for lowest s.w.r. may require some trimming. Start with the antenna length a bit longer than the theoretical length, to allow for some "slack" in tuneup.

Although the inverted Vee can be used as a multiband antenna, it is most effectively employed as a single bander. This is because as the antenna is operated on higher frequencies, radiation angle increases, to the detriment of working DX.

Fig. 1(A) shows basic Vee and inverted Vee configurations.

Palomar Engineers dipole center insulator sports a u.h.f.-type SO-239 coaxial cable connector and a handy hang-up hook, useful for stringing a Vee or inverted-Vee antenna. Stainless steel eyebolts take antenna tension and won't rust. For those who favor use of a balun transformer, a similarly-packaged unit is also available from Palomar. A 1:1 balun can be used to match 50-75 ohm coax to balanced loads (dipoles, Vees or inverted Vees), while a 4:1 balun can be used to match 50-75 ohm line to 200-300 ohm balanced loads (folded dipoles, tuned feeders). (Photo courtesy Palomar Engineers)

The vertical dipole. The dipole is the same antenna, whether installed vertically or horizontally. Mounted horizontally, it will be somewhat directional, depending on its height above ground and the band involved. Sometimes, the horizontal dipole's angle of radiation becomes too high for good results on medium- and long-haul paths.

On the other hand, the vertical dipole presents a horizontal directional pattern that is circular at any wave angle, though to a small extent the vertical-plane pattern will vary with the antenna's height above ground. For the most part, though, it can be considered to be a *low-angle* radiator—favored for DX work on the h.f. bands.

The vertical dipole can be constructed like its horizontal cousin and suspended from a mast, preferably a wooden one. Unlike the more common ¼-wavelength vertical antenna, where the ground beneath it or an artificial ground plane make up for the "missing half," the vertical dipole is full size and its efficiency isn't diminished by a poor ground/ground plane system. However, it is generally too cumbersome an antenna to be practical on the lower h.f. bands, 160 through 20 meters. . . . Still, it's a popular 15- and 10-meter antenna, since it can be made of inexpensive materials, it has a low-angle-of-radiation characteristic (for DX work), and no ground radials need be run or ground plane installed.

Perhaps the most common configuration is the **coaxial dipole,** especially popular on 10 meters and the 27 MHz CB band. In this design, the bottom section of the antenna is constructed of hollow tubing, with the coaxial cable run down the inside of the assembly. Since the r.f. energy is concentrated on the outside of the antenna, the bottom section effectively acts as a shield for the antenna's bottom half. Overall performance of this type of antenna can be outstanding; I have used an adapted Radio Shack CB coaxial dipole for several years and am pleased with the results on 10 meters, having worked into Australia, for example, using a converted s.s.b. CB transceiver running under 25 watts PEP. Too, the fact that the antenna is little more than a 17-foot fiberglass stick makes for a neat, slim-line installation that does not require any unsightly ground plane radials.

The vertical dipole's effectiveness is equivalent to that of its horizontal counterpart. Neither has any "gain" relative to the other, though they may exhibit different horizontal and vertical plane radiation patterns, and they both exhibit approximately 2.1 dB gain with respect to the so-called isotropic or point source (discussed in previous columns). In practice, one type *will* prove superior in different situations and under different conditions. Generally speaking, at practical heights on the h.f. bands, the horizontal antenna will display a higher angle of radiation than will the vertical. This will tend to make the horizontal antenna superior for short-haul work (especially evident on the lower bands, 80 and 40) and the vertical best for DX, with its lower angle of radiation.

Any vertical antenna tends to be more sensitive to man-made static pickup than the dipole, since the lower angle of radiation (and reception) favors signals coming from the antenna's horizon, that is, near the ground level. The vertical is also slightly more susceptible to situations of radio frequency interference (BCI, TVI, etc.). Keep these facts in mind when choosing an antenna.

Fig. 1(B) shows vertical dipole installation details.

Slopers and T2FDs, too. The figure-eight radiation pattern of the horizontal dipole can be varied by sloping the antenna in a semi-vertical position. The sloping dipole, or **sloper,** is popular for long-haul work since the radiation angle is lowered. (A 45-60 degree slope to the ground is typical.)

The higher the feed point is above ground level, the better, since the radiation angle will be lower. If the antenna is supported by a metal mast, maximum radiation will be off the *front* of the antenna. A slight gain in one direction results, since the mast acts as a reflector of sorts. The mast can also create a shielding effect for a

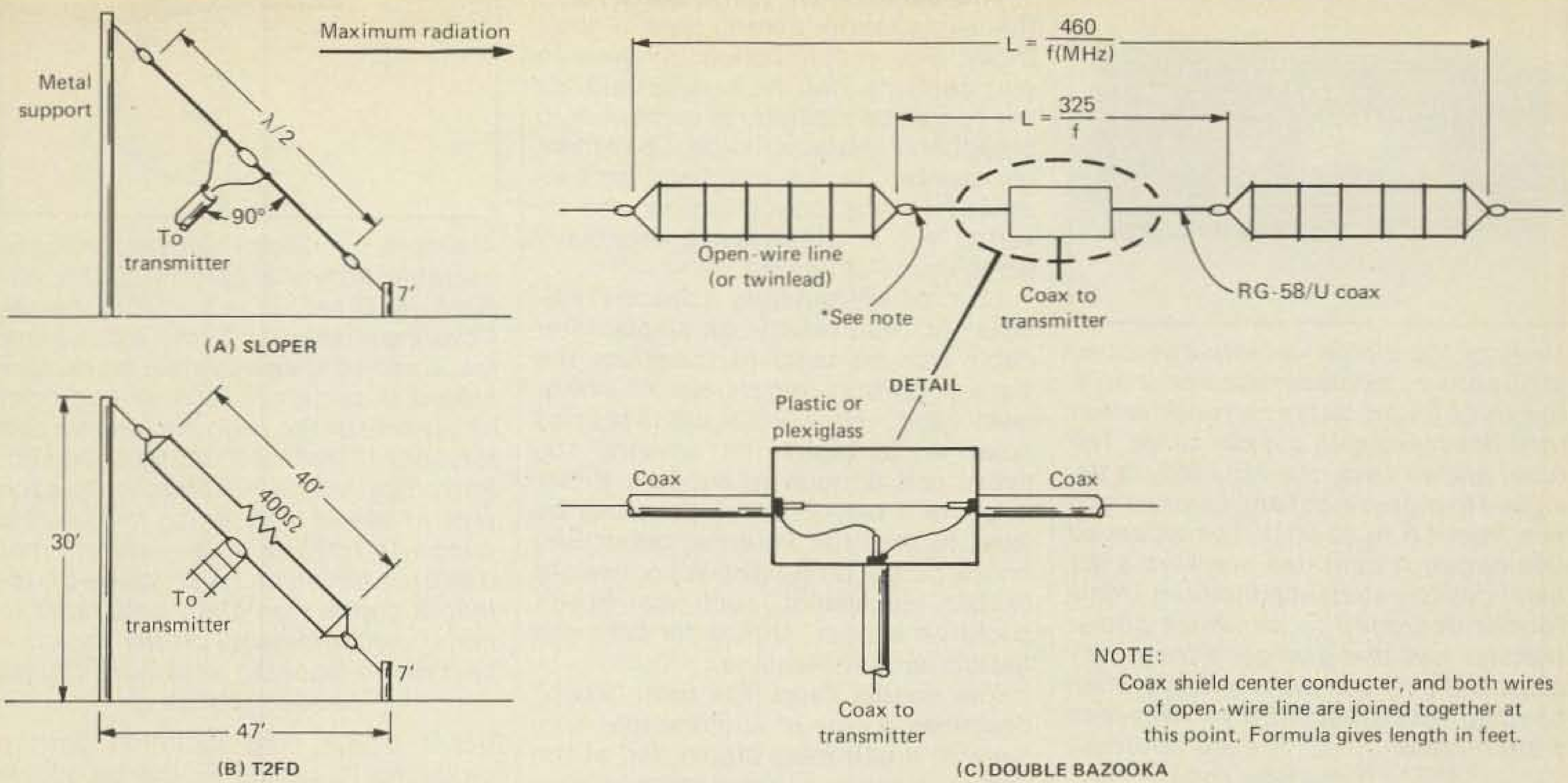


Fig. 2(A)-The sloping half-wavelength dipole exhibits a low angle of radiation. If a metal support is used, maximum directivity will be as shown. If a tree or a wooden support is used, the pattern will be essentially nondirectional.

(B)-The pattern of the T2FD, or "terminated tilted folded dipole," is essentially nondirectional if a wooden mast is used. The dimensions shown at left should result in an antenna that loads well on the 80, 40, and 15-meter bands. Non-inductive resistors with a power dissipation at least equal to ½ the transmitter's power output should be used. The antenna can be fed with coax through a balun, if desired.

(C)-The single-band antenna shown here offers good broadband characteristics. The double bazooka can be installed in practically any configuration. The outer open-wire sections can be replaced by a single wire with a slight reduction in operating bandwidth.

*NOTE: *coax shield, center conductor, and both wires of open-wire line are joined together at this point. Formula gives length in feet.*

deep null off the backside; these characteristics may or may not be desirable. If a non-metallic support is used, the pattern will be essentially nondirectional.

Some amateurs who have high towers installed for their directional arrays use several "guying slopers" spaced equally distant around the tower to take advantage of the varying directional effects possible. A feedline switching arrangement is used to select the proper antenna for the desired direction. Of course, the expected gain is small, though the slight gain improvement coupled with a lowered angle of radiation may justify the installation.

An essentially nondirectional version of the sloper is the so-called **T2FD,** or *terminated tilted folded dipole* (whew!). The T2FD was popularized by *CQ Magazine* designs in the fifties,[1] and though little known today, is still favored by many operators and is being rediscovered by others.

In one popular multi-band T2FD design, the antenna is configured as a folded dipole terminated at a point opposite the feed-point in a non-inductive resistance equal to the feedline impedance (nominally 300-400 ohms). A length of 47 feet is selected for the antenna, which is fed directly with 300-ohm twinline or 450-ohm open-wire feeders. It can also be fed with coaxial cable through a balun transformer. The accompanying illustrations (Fig. 2[A] and 2[B] show construction details for these two designs.

There are, we should point out, many strong believers in slopers and related antennas. Considering the directional possibilities and typically low angle of radiation, sloper enthusiasts rank the antenna higher than the inverted Vee and considerably higher than the conventional dipole when it comes to laying down a good signal at a distant point.

The double bazooka. Not an Army instrument of war, this is a broadband dipole especially popular for 80- and 40-meter work. Based on a radar antenna design by MIT scientists, it was popularized by author W8TV in the July 1968 *QST.*[2]

The double bazooka is constructed as shown in Fig. 2(C). It consists of a ½-wavelength section of coax opened at the center, with the coax feedline connected at that point. The end sections of the antenna are made of open-wire line. In effect, the coax's outer conductor (shield) acts as a halfwave

[1] *Stoner, Donald S., W6TNS. Novice column,* CQ Magazine, *June 1957.*

[2] *Whysall, Charles, W8TV. "Broadside Dipole,"* QST, *July 1968. The design is also described in the ARRL* Radio Amateur's Handbook *from 1969 through 1977. (Footnote refers to a reference on following page #7). Broadband dipoles are also discussed by William Vissers, K4KI, in* 73, *August 1977, p. 36.*

Many of the dipole variants described in this month's column will work best if fed through an antenna tuner rather than direct-fed with coaxial cable. The tuner shown here, the MFJ-962, is designed to match most any antenna system from 1.8 to 30 MHz. The balanced line circuit it contains employs a 4:1 balanced-to-unbalanced (balun) transformer designed to minimize power transfer loss and give good frequency response over the tuner's range when used to feed open-wire or twin-lead transmission lines. (Photo courtesy MFJ Enterprises, Inc.)

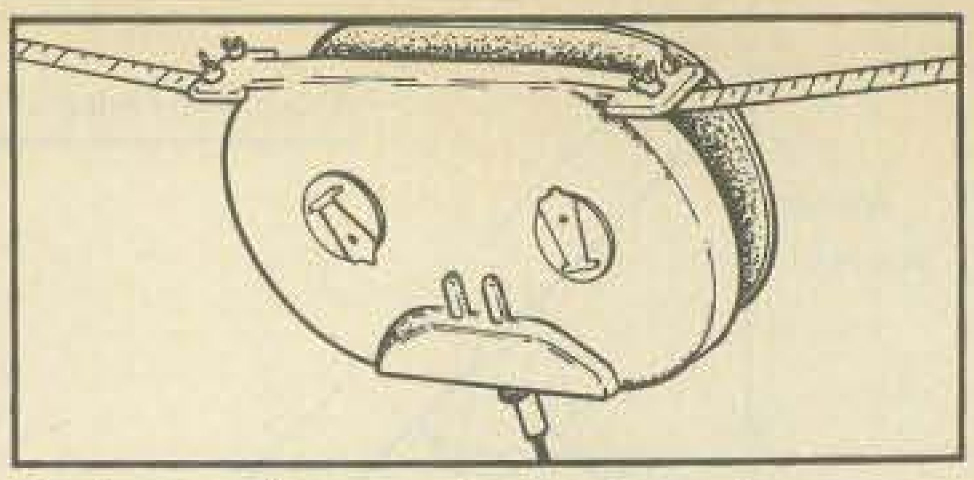
dipole in conjunction with the two open-wire antenna sections. The inside sections act as ¼-wave shorted stubs which present a high impedance at resonance. Off-resonance, the stub feedpoint reactance changes so as to effectively cancel out the antenna's reactance. The net result is an increased operating bandwidth.

The mechanical construction, like the explanation above, gets a little tricky. For simplification, single-wire end sections can be substituted for the open-wire sections at some cost in broadband characteristics. The antenna can be cut for any band and installed in any configuration; the inverted Vee is widely used, especially when space is limited.

Low power-handling capacity RG-58/U or equivalent small-diameter cable can be used to construct the flat-top portion, regardless of power level used. Using large cross-section coax would make the antenna too heavy and difficult to support. Either large- or small-diameter coax can be used to feed the antenna, depending on the power level used. A lightweight RG-8/U equivalent such as RG-8X could be a good choice for both the flattop and the feedline.

The double Zepp. The term "Zepp" describes a type of antenna that consists of a half-wave dipole, fed at the end through a ¼-wave transmission line, originally used on the early Zeppelin airships. The antenna later became a favorite with amateurs.

A variation of the end-fed Zepp is the so-called **double Zepp.** Commonly called the full-wave dipole, two half-waves in phase, or the two-element collinear array, the double Zepp yields a gain of about 2 dB over the conventional dipole. The radiation pattern produced is similar to the broadside figure-eight pattern of the dipole.



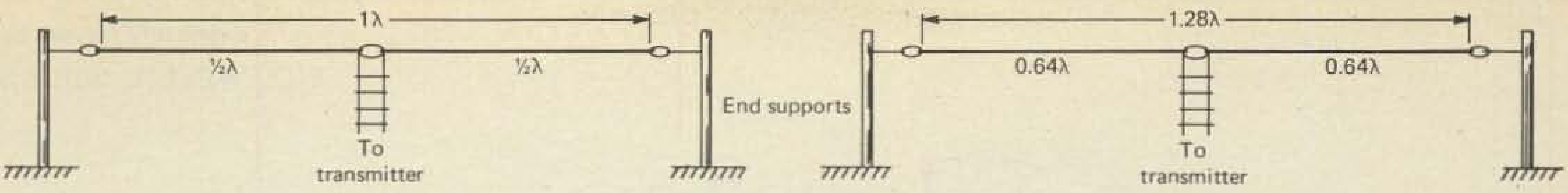
A simple, but useful high-performance portable antenna system is this Hy-Gain 18TD reel tape portable dipole. Covering 80 through 10 meters, the unit features two stainless steel tapes, calibrated in meters, which extend from either side of the main housing up to a total of 132 feet for 80-meter operation. Polypropylene rope is attached to each tape to permit installation to available supports to form a semi-permanent doublet antenna. A frequency-to-length conversion chart calibrated to meter measurements on the tape is a part of the housing assembly. (Photo courtesy Hy-Gain)

Normally, the antenna is fed with open-wire line (tuned feeders) and routed through an antenna tuner or coupler located at the transmitter. A matching section can also be used at the antenna feedpoint to allow coaxial cable to be used as the transmission line.

The extended double Zepp. Going a step further, the *1.28-wave dipole* is known as the extended double Zepp. In keeping with collinear antenna design principles, making the antenna slightly longer than a full wavelength will increase gain somewhat. The optimum length for each element is 0.64-wavelength, and results in about a 3 dB gain over the ½-wave dipole. The radiation pattern is, again, the familiar figure-eight, but directivity is considerably more pronounced. Like the full-wave dipole, the extended double Zepp is usually fed with open-wire line.

Fig. 3 shows construction details of both the double and extended double Zepp.

The dipole antennas we have discussed are particularly suitable for the beginner, as opposed to single-wire and long-wire types that are often recommended as "first antennas" due to their apparent simplicity. The resonant, balanced-to-ground characteristic of the dipole fosters easy transmitter loading and tuneup, although some designs require feeding through an antenna tuner. The single-wire's unbalanced nature and its typically nonresonant characteristics tend to combine to present loading and grounding problems that the Novice operator may not be prepared to solve. Too often, the lack of a proper ground system, required for the single-



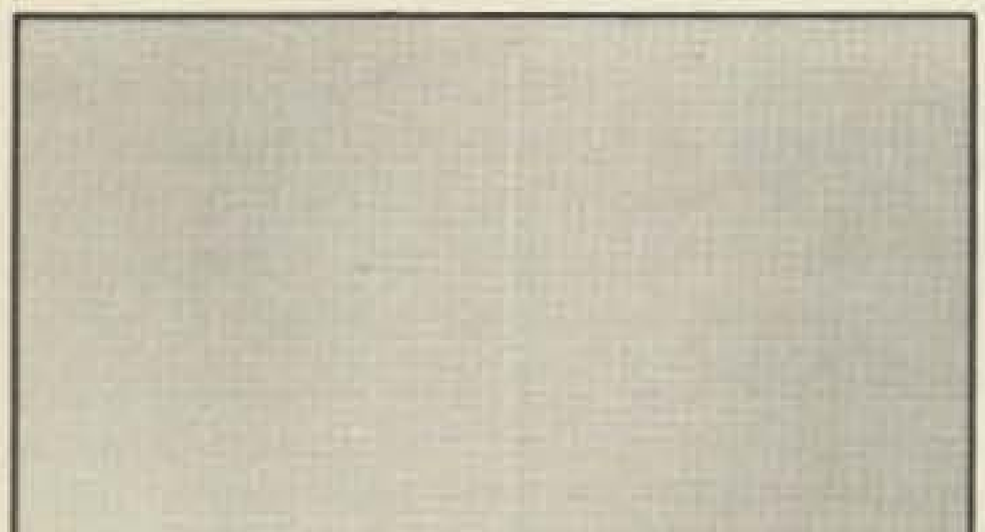
(A) DOUBLE ZEPP

(B) EXTENDED DOUBLE ZEPP

Fig. 3(A)-Shown above is the double Zepp, a full-wave dipole sometimes referred to as a "two half-waves in phase" antenna. Normally fed with open-wire line, it must be fed through an antenna tuner at the transmitter. Its advantage is about a 2 dB gain over the half-wave dipole, the penalty that it requires twice the horizontal space as the dipole. Its vertical counterpart is the ½-wave vertical, which boasts a 2 dB gain over the ¼-wave vertical.

(B)-The extended double Zepp, shown above, is 1.28-wavelengths long. It, too, is usually fed with open-wire line through an antenna coupler. It boasts slightly higher gain, about 3 dB over the standard ½-wave dipole, and it requires more than twice the space. Its vertical counterpart is the 0.64-wave vertical, which sports about 3 dB over the ¼-wave vertical.

The 1- and 1.28-wave dipoles require a great deal of space, as indicated, which is a particular drawback on the 160, 80 and 40-meter bands. When space is limited, the ends can be bent horizontally or vertically to meet the dictates of available real estate. However, there will be some loss of effectiveness and complication of the radiation pattern.



One of the most popular versions of the vertical dipole is the coaxial antenna, shown here. Configuration eliminates the need for ground-plane radials. Radiation pattern is low-angle and omnidirectional. Author has used the CB-type antenna of the kind shown here with excellent results on 10 meters.

(Photo courtesy Radio Shack)

A close cousin to the dipole is the ferrite rod directional loop, especially popular as an m.f./h.f. receiving antenna. McKay Dymek loop shown here contains a FET two-stage amplifier and it's designed to minimize interference and background noise prevalent in m.f. reception. This particular antenna is designed for broadcast band use, but higher-frequency versions are also available. Commercial quality receiving loops are also sold by Palomar Engineers. (Photo courtesy McKay Dymek)

wire, results in equipment that is hot with r.f. when touched, erratic loading conditions, r.f. feedback in station accessories, and increased probability of BCI and TVI. Working with dipole-type antennas reduces the chances for such undesirable consequences.

This concludes—at least for the moment—our two-part discussion of the dipole and related antennas. We've run the gamut, having covered the basic dipole, the odd-harmonic radiator, the folded dipole, the Vee and inverted Vee, the vertical dipole, the sloper, and T2FD, as well as the double bazooka. And, we've also touched on both double and extended double Zepps.

It's good at this point to mention the parallel relationships between the basic ½-wave dipole, the double Zepp, and the extended double Zepp, and their vertical counterparts. These are the ¼-wave, ½-wave, and 0.64-wave vertical, respectively. The basic ¼-wave vertical exhibits unity gain, whereas the latter two designs yield 2 and 3 dB gain over the ¼-wave. The long verticals, of course, derive their gain figures from an improved low-angle radiation characteristic, rather than through increased horizontal-plane directivity.

Next month, we'll shift gear. Featured will be a discussion of popular h.f. vertical antenna designs and some practical advice on their selection and use. Stay with us.

73, Karl, W8FX

P.S. — We expect, in a few months, to run columns featuring such diverse topics as SWL antennas, dummy loads, scanner radio antennas, switching arrangements and devices, antenna accessories, limited space aerials, cubical quads, portable antennas for the traveler, mobile antennas (h.f. and v.h.f./u.h.f.), longwires, and antennas for 160 meters. I invite readers to send along photos and descriptions of their installations; if the photos are of good quality and the design of broad interest, we'll try to run the photo and description sent in. The photos should be extras, since it's impractical to ensure their safe return.

a monthly feature by
KARL T. THURBER, JR., W8FX

Antennas

DESIGN, CONSTRUCTION, FACT, AND EVEN SOME FICTION

HF Verticals, Plain And Simple

In last month's column, author W8FX concluded a two-part discussion of variations on the dipole antenna. Included were facts on Vees and inverted Vees, vertical dipoles, slopers, T2FDs, double bazookas, double Zepps, and extended double Zepps. In this issue, he embarks on another two-part spread covering popular h.f. vertical designs. This month, the simpler forms.

Band	Frequency (kHz)	Use	Driven Element	Radials
160	1850	160-low	126′ 6″	129′ 9″
160	1950	160-high	120′ 0″	126′ 4″
80	3600	C.W.	65′ 0″	66′ 8″
80	3725	Novice C.W.	62′ 10″	64′ 5″
80	3750	Mid-Band	62′ 5″	64′ 0″
75	3850	Phone	60′ 10″	62′ 4″
40	7075	C.W.	33′ 1″	33′ 11″
40	7150	Mid-band	32′ 9″	33′ 7″
40	7175	Novice C.W.	32′ 8″	33′ 6″
40	7225	Phone	32′ 5″	33′ 3″
20	14050	C.W.	16′ 8″	17′ 1″
20	14175	Mid-band	16′ 7″	17′ 0″
20	14275	Phone	16′ 5″	16′ 10″
15	21075	C.W.	11′ 2″	11′ 5″
15	21175	Novice C.W.	11′ 1″	11′ 4″
15	21225	Mid-band	11′ 1″	11′ 4″
15	21350	Phone	11′ 0″	11′ 3″
10	28050	C.W.	8′ 5″	8′ 7″
10	28150	Novice C.W.	8′ 4″	8′ 7″
10	28750	Phone-low	8′ 2″	8′ 5″
10	29075	Phone-high	8′ 1″	8′ 4″
10	29475	OSCAR (receive)	8′ 0″	8′ 2″

+ Dimensions, which are approximate, are rounded to next higher inch.

+ Driven element dimensions are derived from the formula $f \text{ (in feet)} = \frac{234}{f(\text{MHz})}$

+ Radial dimensions are derived from the formula $f \text{ (in feet)} = \frac{240}{f(\text{MHz})}$

Fig. 1- Quarter-wave vertical antenna lengths.

Put any two DX'perts together and begin a discussion of antennas and you're almost certain to trigger a heated exchange on the merits of vertical vs. horizontal polarization. We don't really want to get into the thick and heavy regarding the pros and cons of these two antenna types just now, other than to make a few general comments. So let's lay the groundwork.

Horizontal vs. vertical polarization. Because of its economy and simplicity, the vertical antenna has long enjoyed popularity within the amateur community. Its appearance is usually neat, it's suitable for multiband operation, it doesn't require a great deal of horizontal space, it's relatively easy to construct, and it's not normally hard to adjust. But what about performance?

On the lower h.f. bands, 160 through 40 meters, the vertical is hard to beat, and in fact can work surprisingly well if it is mounted unobstructed by foreign objects, has a good ground system, and is properly matched to the transmission line. At practical heights, the vertical antenna lays down a very low-angle, horizon-hugging signal in all directions, which favors transmission and reception from distant points. Polarization, *per se*, is not a big factor in h.f. skywave propagation, due to the nature of the ionosphere, which mixes signal polarization.

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Compared with a horizontal antenna at heights of 30 to 40 feet, the vertical will *usually* perform better over longer distances—around 700-800 miles and up, whereas the horizontal will normally turn in a better performance over shorter distances. On the lower bands, where full-size ¼-wavelength antennas are often impractical, a shorter radiating element may be used, but this wastes power in the loading coil used to resonate the antenna.

Nearby objects, such as buildings, trees, and utility wires, can also absorb energy and upset the radiation pattern. It may be helpful to elevate the antenna above the obstructions, by installing it on a roof or mast. This may be done if an artificial *ground plane* is installed, as will be described later.

While the vertical's low-angle-of-radiation characteristic is a desirable one, the omnidirectional pattern becomes a disadvantage when working DX. One's power is spread across the compass, rather than being concentrated in the desired direction. Reception suffers in that signals from all directions are received equally well, and man-made noise seems to be

picked up stronger on the vertical. On the higher h.f. bands—20, 15, and 10—where multi-element antennas take on manageable dimensions, a Yagi beam or Quad will easily outperform the vertical and dipole alike.

A final point: The vertical polarization and low angle of radiation can aggravate television interference (TVI) and broadcast interference (BCI), as well as problems caused by r.f. getting into nearby telephone lines and hi-fi equipment. Be aware that vertical polarization used in crowded urban quarters may cause problems along these lines.

Vertical antenna theory and some basic designs. The vertical is popular on the h.f. bands, since it's possible to obtain low-angle radiation for both local (ground wave) and DX work. if installed with its bottom end less than ¼-wavelength high and operated over a reasonably conductive ground, it's indeed a good performer. In fact, the vertical is almost exclusively used for broadcast and many h.f. point-to-point circuits. It produces high current density in the ground beneath and around it, however, and therefore requires an extensive ground system—as many as 120 radials in broadcast service (more on this later).

Vertical antennas are commonly of ¼-, ½-, or 5/8 to 0.64-wavelength. The longer antennas produce some gain relative to the basic ¼-wave; for example, the ½-wave vertical yields about a 2 dB gain, and the 5/8-wave radiator a 3 dB gain. The height required, as well as the non-standard feedpoint impedance (which requires a base matching device), makes them unwieldly except on the higher bands, 15 and 10 meters, and on the 27 MHz CB frequencies. Thus, most popular h.f. verticals are of the Marconi or resonant ¼-wave type. When the antenna is cut to ¼-wavelength, the feedpoint impedance is approximately 35 ohms, allowing a fair match to popular 50-52 ohm cables without the use of tuning coils or other matching devices. The antenna can be shuntfed or series-line matched to effect a near-perfect impedance transformation over all or a considerable portion of a band.

The ¼-wave vertical is mainly a single-band antenna, although a 40-meter vertical will take power on 15, an especially attractive situation for the Novice. In this instance, the 40-meter ¼-wave turns out to be three-quarter waves on 15. (Any odd multiple of quarter waves will allow relatively low-impedance feed directly with coaxial cable.)

The vertical physically consists of two components, the driven element and the ground connection or ground plane. The approximate driven element length is derived from the equation

$$L \text{ (in feet)} = \frac{234}{f \text{ (MHz)}}$$

This length is only approximate, since *exact* resonance will be determined by the diameter of the wire, tubing or rod used to construct the antenna. Buried radials need not be resonant, but those installed above ground should be slightly longer than the driven element. Their dimensions are given by the formula

$$L \text{ (in feet)} = \frac{240}{f \text{ (MHz)}}$$

Fig. 1 shows formula-derived driven element and radial lengths for each h.f. amateur band.

For multiband operation, except for the special 40/15 meter situation, a base loading coil is used to tune out the antenna's reactance. The typical base-loaded vertical is simply a piece of tubing, 16-25 feet long, with a tapped inductor at the bottom to allow *manual* resonating on each band or band segment. Be aware that adjustment is required *at the antenna's base*

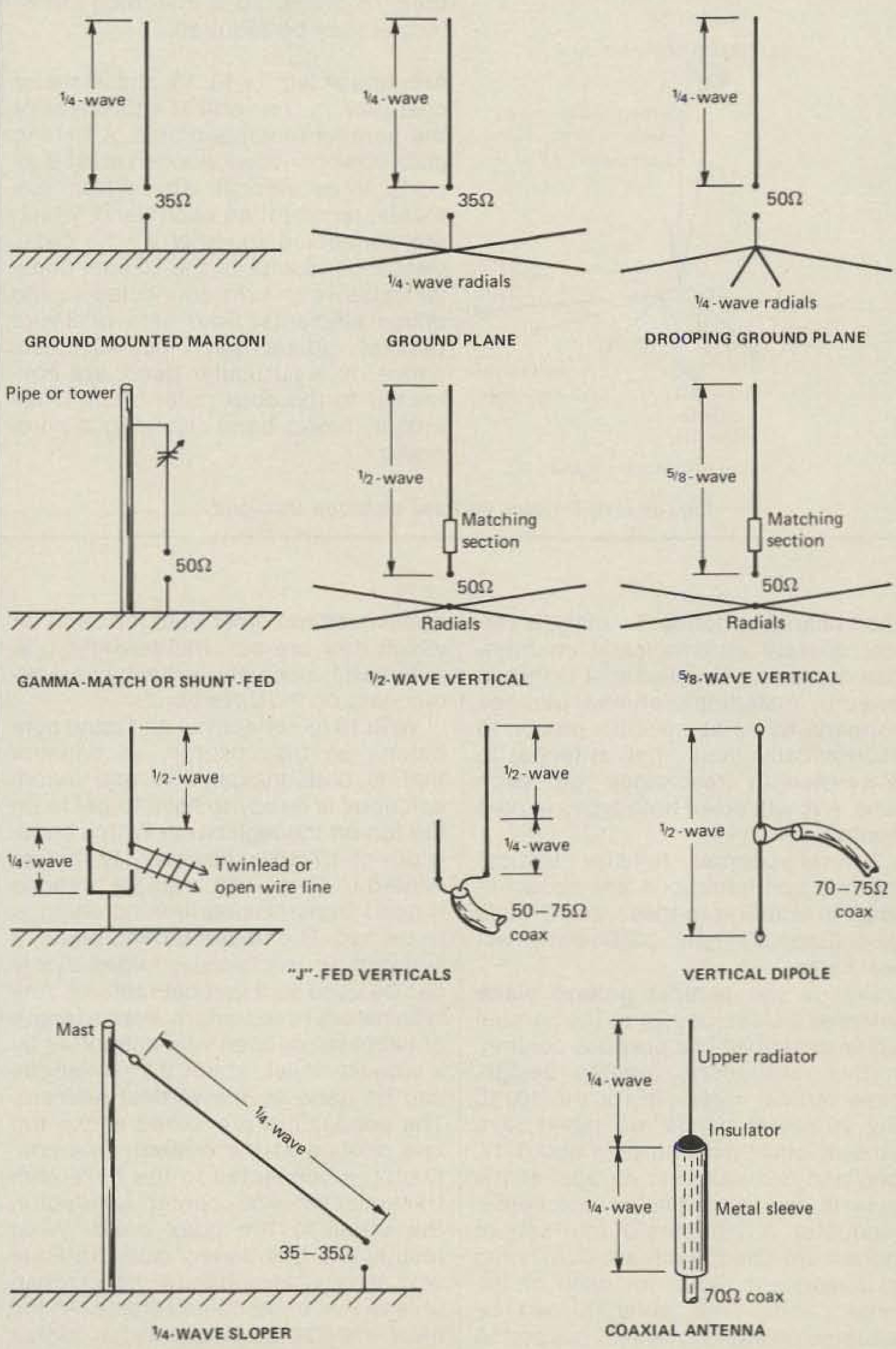
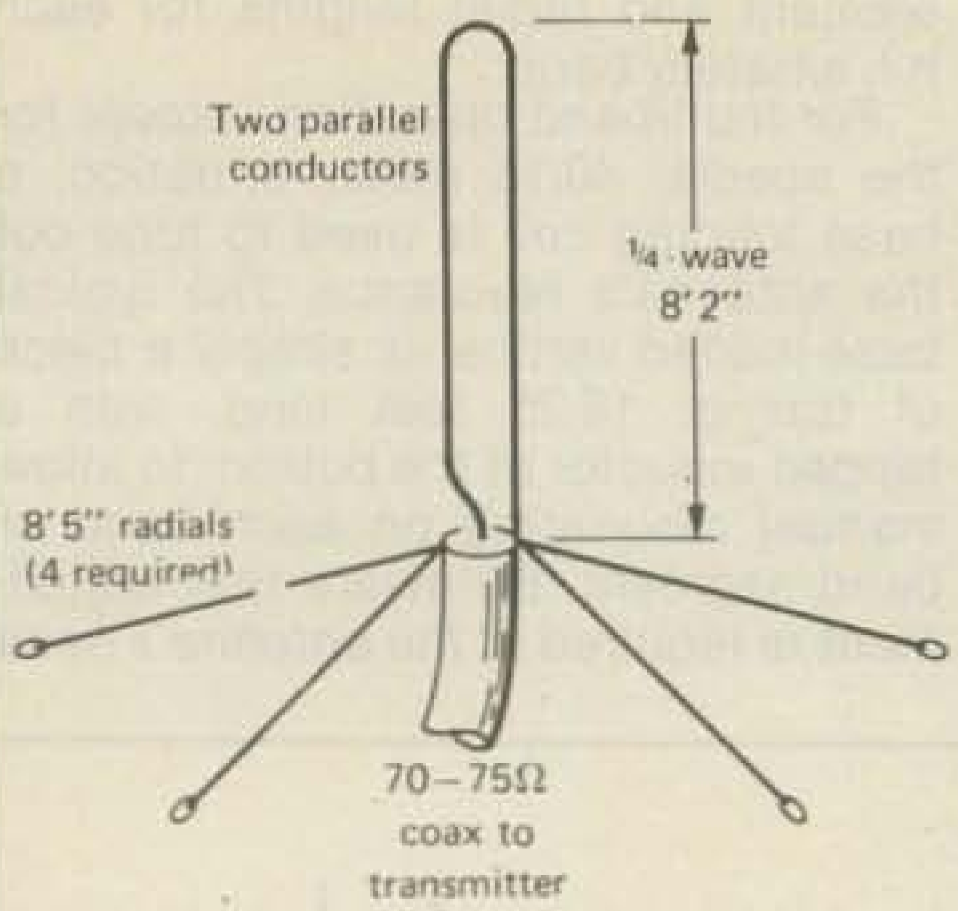
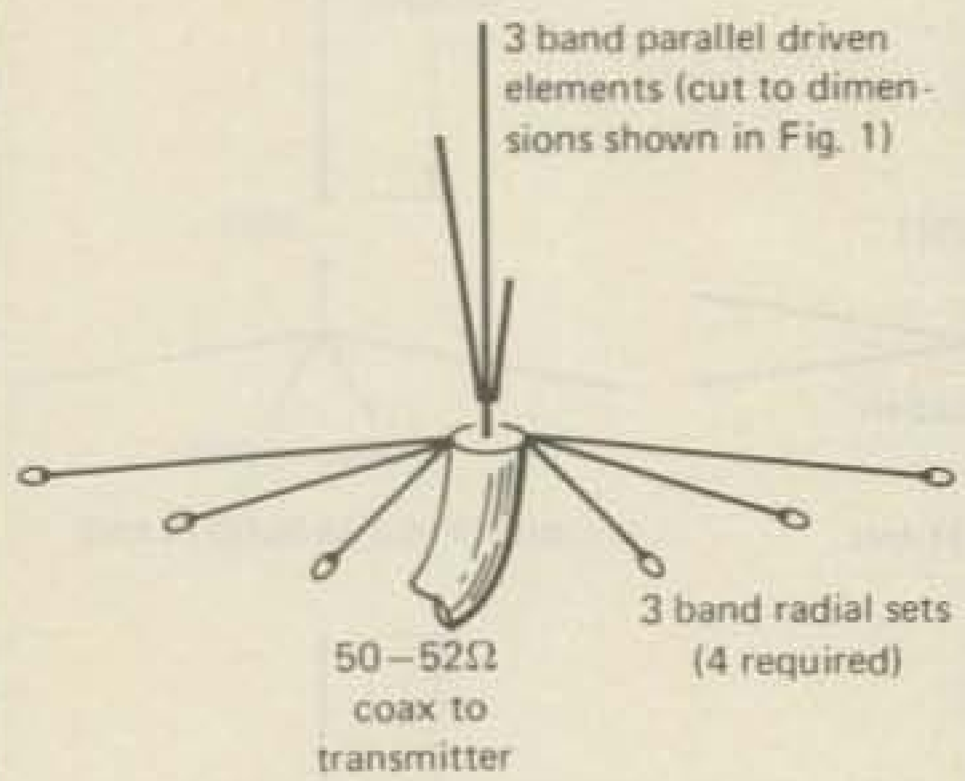


Fig. 2- Representative vertical antenna configurations. Note: Impedances are approximate and the drawings are not to scale.



(A) FOLDED GROUND PLANE

The trombone-shaped 10 meter antenna at left is made from two parallel conductors, joined at the top and separated at the bottom. One is connected to the coax lead-in's center conductor, the other to the braid shield and radials. Copper or aluminum tubing can be used to form the driven element, as can 300-ohm TV-type twinlead or 450-ohm open-wire line. This broadband antenna should allow coverage of the entire 10-meter band with acceptably low s.w.r. Feedpoint impedance is slightly higher than 75 ohms, so a matching transformer may be required.



(B) PARALLEL GROUND PLANE

Antenna at left for 10, 15, and 20 meter operation is the vertical equivalent of the parallel multiple dipole. A fishing pole, dowel or other wooden mast supports three vertical wire driven elements, resonant on each band, which are connected together at the base. Center conductor of the 50-ohm coaxial cable is in turn connected to the driven elements. Four sets of 3-wire parallel radials, each cut for resonance on a particular band, are connected to the coax outer braid. Once initially tuned, band changing is automatic.

Fig. 3- Two unique vertical antenna designs.

when changing bands. To make a vertical operate *automatically* on more than one band, the electrical length is varied by installing pretuned, parallel-resonant traps at specific points to electronically "cut" the antenna to ¼-wavelength resonance on each band. (We will cover both types in next month's column.)

Several popular full-size vertical antenna configurations are shown in fig. 2. In addition to these, two simple specialized designs particularly appeal to me.

One is the **parallel ground plane antenna,** a close cousin to the parallel dipole described in a previous column. In this inexpensive, no-trap design, three vertical wires cut for the 10, 15 and 20 meter bands are taped to a cane or other wooden pole about 17' long and connected *in parallel* at the base to the transmission line center conductor. A minimum of four sets of radials are used, each set consisting of a resonant radial for each of the three bands. The antenna can be mounted on any convenient support. A good match to coax is possible on each band without adjustment after initial trimming; the nonresonant driven elements have a high impedance and are therefore practically nonexistent on other than the band for which they are cut. Bandswitching is automatic since the antenna is self-resonant on the three bands.

With 10 meter activity and band conditions on the upsurge, an antenna that is both inexpensive and inconspicuous is handy to have to get in on the fun on the high band. With a bandwidth of 1.7 MHz, however, 10 meters is hard to cover with a single antenna if good transmission line matching is to be had. The **folded ground plane**, a variation of the familiar *folded dipole* can be used as a vertical radiator. Any type parallel conductors, even a length of twin-lead or open wire supported by a wooden mast, about 8'2" in length, can be used as the vertical element. The conductors are joined at the top and opened at the bottom. One conductor is connected to the 70-75 ohm transmission line center conductor, the other to the coax braid. What results is a trombone-shaped antenna with a very wide bandwidth comparable to that of the folded dipole. As the base impedance is somewhat higher than 70 ohms, a matching network may be required for low s.w.r.

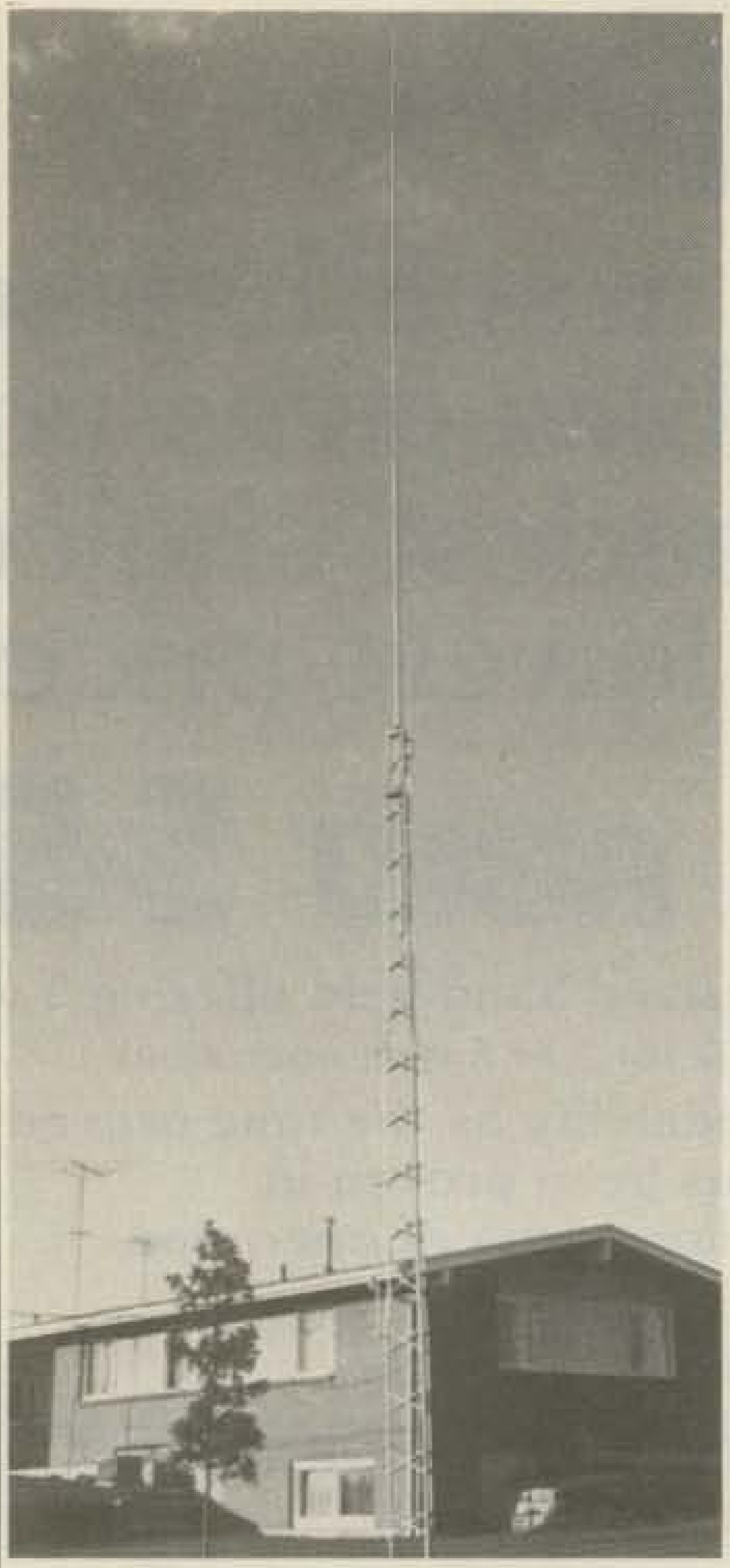
Both of these two interesting designs are shown in fig. 3.

Don't forget the ground. With most verticals, operation against a low-resistance ground is a "must" if the antenna is to radiate better than the proverbial wet string. Indeed, the importance of an efficient ground system for the vertical can't be overemphasized. Why is this so?

The vertical, in its simplest form, is designed to be *electrically equivalent* to a dipole stood on end. When mounted close to the ground, the earth takes the place of the "missing half" of the dipole. The antenna can work effectively in this mode only if there is a low-resistance connection to ground, since the ground circuit resistance, along with the radiation resistance of the antenna, determines the amount of current flowing in the antenna circuit and therefore the power radiated. A ground circuit resistance of more than a few ohms will substantially detract from the mirror effect the earth is to provide and can result in extremely low antenna frequency—possibly as low as 10%. To secure a good ground, rods, wire mesh screens, and radial wires are used.

If local conductivity is exceptionally good or if the soil beneath the antenna is chemically treated to increase conductivity, a simple 4-6' metal stake *may* serve as the ground connection. Far better and more efficient are ground wires arranged in the form of wagon wheel spokes radiating from the central ground rod, with each radial preferably terminated in a ground rod. Wire size or type conductor is unimportant; the radials do not have to be of any particular length, they do not have to be laid in a straight line, and they don't even have to be buried. A large number of *long* radials is better in reducing ground losses that a number of *short* ones. However, since the largest losses occur in the ground near the base of the antenna (where current flow is highest), it's better to use a larger number of radials of shorter length than a smaller number of longer ones, for a given amount of wire. Wire mesh (such as chicken-wire screening) can be used effectively under the antenna, in the area of highest ground loss.

If a good ground can't be obtained, of if the ground mounted antenna would be surrounded by power-absorbing objects, you can mount the antenna atop a mast or on a roof, installing your own artificial ground system (ground plane) under the vertical. The antenna is supported by at least four ground plane radials, installed at the base of the elevated antenna and connected to the braid of the coax and to the supporting tower or mast (if metal). The ground plane radials should be ¼-wave-



Antenna of the Month: Hy-Gain 18HT Multiband H.F. Vertical

The Hy-Gain 18HT is a full-size, automatic bandswitching vertical which covers 80 through 10 meters. It features a stub decoupling system which effectively isolates various sections of the antenna so that an electrical ¼-wavelength (or odd ¼-wavelength multiple) appears on all bands. With the addition of a base loading coil, the antenna can also be used on 160 meters.

The galvanized 24′ tower requires no guying in winds up to 75 m.p.h. The top mast is constructed of 6063-T832 taper swagged aluminum that extends the antenna to an overall height of 50′. A special hinged base assembly allows complete assembly at ground level and easy raising and lowering.

The matching system employed allows an s.w.r. of less than 1.5:1 to be attained at resonance on all bands (80 through 10 meters). Typical 2:1 s.w.r. bandwidths are 700 kHz on 10; 300 kHz or better on 15, 20 and 40 meters; and 250 kHz on 80 meters.

length for the band to be used. They should be insulated at the far ends and separated from guy wires by egg insulators.

Four or more radials provide an effective ground plane mirror for the antenna, and they also act as decoupling stubs to choke off current flow on the mast used for support. The radials may be run parallel to the earth or sloped downward; sloping them at a 45-degree angle will raise the feedpoint impedance, possibly allowing a direct match to 52-ohm cable without the use of a matching device. For multiband operation, paralleled radial sets should be used for each band, though 40 meter radials will suffice for 15-meter operation due to their odd-harmonic resonance on the higher band. (Multiple conductor TV rotator cable or twin-lead can be used for the parallel radials if the conductors are peeled back to form ¼-wave radials on each band.)

In difficult apartment or business locations, where the antenna can neither be ground mounted nor used with an artificial ground plane, you may still be able to use a vertical if you can find a large mass of metal close by the antenna base that has a direct or capacitive-coupling to ground, such as air conditioning or heating systems, structural steel frames, downspouts, etc. Windowsill-mounted "semi-verticals" may be used where roof-mounted antennas are prohibited, if a cold-water pipe or radiator connection can be found and/or if tuned radials or a *counterpoise* is used for r.f. grounding. The metal bodies of trailers, mobile homes and campers may be used as parts of a ground system for verticals. Results are unpredictable and will likely vary from band to band. On-the-air performance depends to a large measure on one's dogged persistence in trying to secure an effective ground system.

Antenna of the Month

Beginning this month, and from time to time in subsequent columns, we will feature an "antenna of the month." We'll pick an unusual commercial antenna design and review its technical details for the benefit of *CQ* readers who may be contemplating purchase. In the future, we may be able to include unique homebrew designs, so if you have a special design you are particularly proud of and want to share it with other readers, send along a technical rundown. Good photo and sketches are a must.

See you then.

73, Karl, W8FX

a monthly feature by
KARL T. THURBER, JR., W8FX

Antennas

DESIGN, CONSTRUCTION, FACT, AND EVEN SOME FICTION

More On H.F. Verticals: Getting Fancy

Last month, author W8FX began a discussion of h.f. vertical antennas. He covered the merits of vertical vs. horizontal polarization, basic theory and full-size designs, as well as grounding and matching requirements. This month, he goes on to discuss popular variations on basic vertical designs.

-K2EEK

Last month we covered basic h.f. vertical antenna design and theory. We also highlighted straightforward vertical designs, including two of my favorites, the folded vertical and the no-trap multiple vertical. This month's column continues the article which began last month. We will go on to discuss shortened and loaded verticals, including mobile antennas and base loaded multibanders.

Let's go into what happens when we substantially shorten the vertical from "reasonable" lengths of ¼-wavelength or longer to mini-sized configurations.

Shortened/Loaded Verticals

While quarter-wavelength or longer antennas make for more efficient radiators, shorter verticals can still be effective radiators as long as they possess an adequate ground system, don't exhibit excessive loading coil losses, and show a reasonably good match to the transmission line.

A very short vertical has a low radiation resistance and a high "Q" or selectivity factor. At all frequencies lower than the antenna's self-resonant frequency, it electrically looks like a low resistance in series with a high capacitive reactance. In order to resonate the antenna to the desired frequency and to match the antenna to a convenient transmission line impedance (such as 50-75 ohms), the reactance must be cancelled out and an impedance transformation accomplished. This calls for the use of a series loading coil or L/C network.

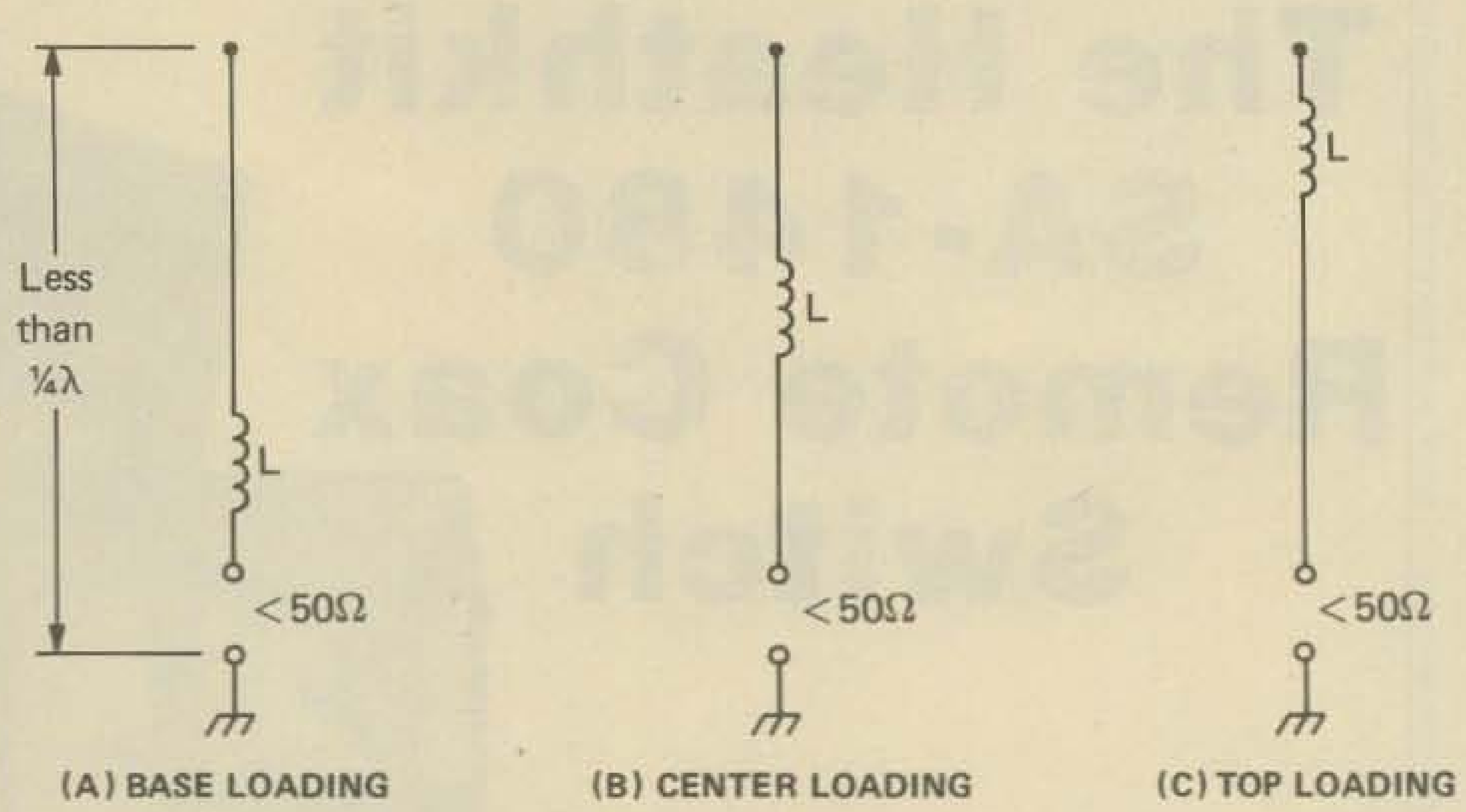


Fig. 1-The shortened/loaded and mobile vertical antennas.

Three representative classes of shortened verticals are shown above.

The electrically short antenna shows high Q (selectivity factor), and a low radiation resistance. The capacitive reactance which is present is tuned out and the antenna resonated by means of a series loading coil. The coil may be mounted at any point, though base loading (A) is usually most convenient, and is usually done with fixed station antennas. Center loading (B) is more efficient, and top loading (C) is the most efficient—though the least convenient, mechanically speaking. A "top hat" may be added to reduce the size of the loading coil required and thus to minimize coil losses. Continuously-loaded, helically-wound coils have also been used with some success. The idea is to make the coil as small as possible and to raise the point of maximum current in the antenna as high as possible above ground.

The same principles apply to mobile antennas—only more so. The typical, 8-foot, center loaded whip becomes inefficient and extremely unforgiving of even small QSYs; feedpoint impedance is quite low and can be very difficult to match to coax.

A quarter-wave vertical has an impedance of about 35 ohms. An acceptable match can be effected by direct connection to coax cable, or an r.f. transformer or base-matching circuit can be used for more effective power transfer from transmission line to antenna. However, when the length of an antenna is physically reduced with respect to wavelength, the radiation resistance is also lowered. For example, a 0.2 wavelength antenna has an impedance of about 18 ohms, showing capacitive reactance. A very short vertical, for instance, a 16-foot antenna on 80 meters, will show a radiation resistance of but a few ohms; coupled with high capacitive reactance, it's hard to match. Since radiation resistance is low relative to the ohmic resistance of the antenna, the radiator becomes a very inefficient one—with most of the power wasted in the form of heat.

If size reduction is not carried to the extreme, decent results can be had with shortened antennas if a

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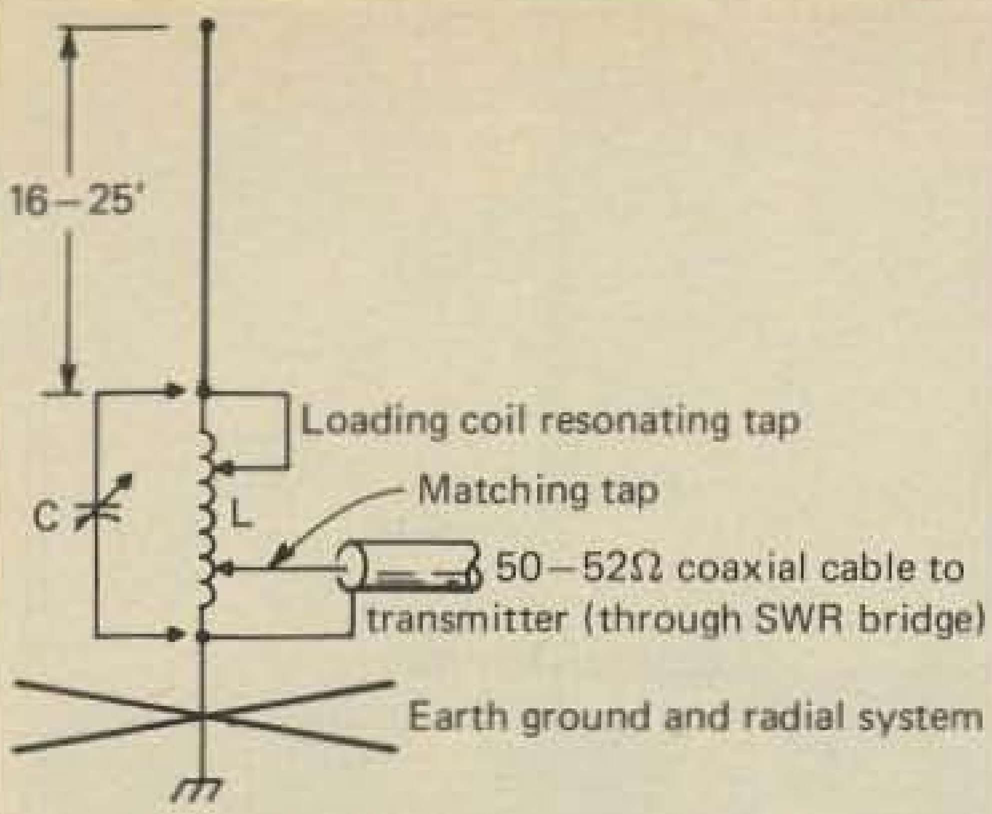


Fig. 2–Base loaded multiband verticals.

Typical base loaded multiband vertical antenna. In this antenna design, a loading coil is installed at the base of a vertical length of wire, tubing or rod about 16-25′ long to enable the antenna to be manually resonated on several bands.

Inexpensive and especially suited to home construction techniques, a couple of 10′ TV mast sections can make up the radiating element, which is supported by a beverage bottle or by ceramic insulators. For 80-10 meter operation, the inductor (L) is usually about 30 turns of 2-3 inch diameter coil stock. The capacitor (C) is a maximum of 100-150 pf. and is used only if a good match to the transmission line can't be obtained without its use. An "L"-network can be used to resonate the antenna, and a wideband r.f. transformer can be used to secure an impedance match.

Several manufacturers sell low-cost multiband verticals incorporating the base loading principle.

high-Q loading coil is used to minimize losses, provided the resultant narrow operating bandwidth is acceptable. An antenna slightly less than 1/8-wavelength is about the shortest that should be used for good results; 24 feet is about the minimum for really good 75/80-meter operation. The very low base impedance—around 15 ohms for a 25′ vertical on 80 meters—is difficult to properly match to coax, though one of the new r.f. transformers (as offered by Palomar Engineers, SST Electronics, and Swan) should fill the bill. The Palomar transformer, for example, has taps at 8, 12.5, 16, 22, 32 and 50 ohms, allowing close matching of almost any shortened vertical to coax.

The problems of the shortened vertical are magnified when considering mobile antennas. On all bands except 10 meters, where a standard 8′ whip works out to full quarter-wave resonance, the antenna is extremely short relative to wavelength; longer whips are not usually practical since they risk hitting obstructions. The efficiency of a loaded antenna drops off markedly on the lower bands, especially on 75 and 160 meters, because the resistance of the loading coil assumes a large proportion of the total resistance into which the transmitter output power is fed. No one likes to mention it, but radiation efficiency on 75 meters can drop to 3% or less—compared with nearly 100% for a full-size, half-wave dipole.

Antenna efficiency can be substantially improved (by 50% or more) by moving the loading coil from the base to the center of the antenna. Adding a capacitive "top hat" decreases the size of the loading coil required, and therefore increases the overall efficiency of the antenna system. However, on the lower bands, the Q (selectivity factor) of an efficient antenna is so high that it's necessary to retune the antenna for even small QSYs (changes in frequency)—as little as 10 kHz on 160 or 75 meters—if efficiency and low s.w.r. are to be maintained. With most mobile antennas, changing bands means changing coils and/or top sections, although there are a few *multiband* antennas available and several schemes have been devised for remote resonating and bandswitching from the driver's seat.

Mobile antenna tuneup is much trickier than adjusting fixed station antennas. A good s.w.r. bridge and dummy load/wattmeter, and possibly a grid dip oscillator or antenna noise bridge, are practical necessities. Achieving a good feedpoint match is even more important than with the shortened fixed station vertical, since mobile whip impedance may be 10 ohms or less. Needless to say, when it comes to h.f. mobile antennas, a little extra effort to reduce unnecessary system loss may increase your ability to "work out" more than any other improvement you can make.

Of interest to the apartment dweller and renter where a windowsill antenna is the only possibility, a number of amateurs have effectively used standard mobile coil-and-whip combinations, mounting them as windowsill semiverticals. At least one manufacturer, Barker and Williamson, has come up with a *portable* base loaded antenna system that covers the 2- through 40-meter bands using several interchangeable coils and a 57″ whip. Since it's almost impossible to secure a real "r.f. ground" in an apartment, antennas of this kind are usually not truly grounded, but are instead fed against an insulated, artificial ground

Precise s.w.r. adjustment is important to proper resonating and efficient tuning and matching of short mobile whips. The Swan SWR-3 "pocket" s.w.r. meter is a compact, lightweight device intended for mobile or portable use. Directional coupler measures 1:1 to 3:1 s.w.r.s at 50 ohms with 3% accuracy from 1.7 to 55 MHz. (Photo courtesy Swan Electronics)

known as a *counterpoise.* Ground system and antenna adjustment can be tricky, and it's especially difficult to keep the shack free of "floating r.f." caused by poor impedance matching and the strong r.f. fields that are induced in metal objects, including station equipment.

Fig. 1 shows representative shortened antenna types.

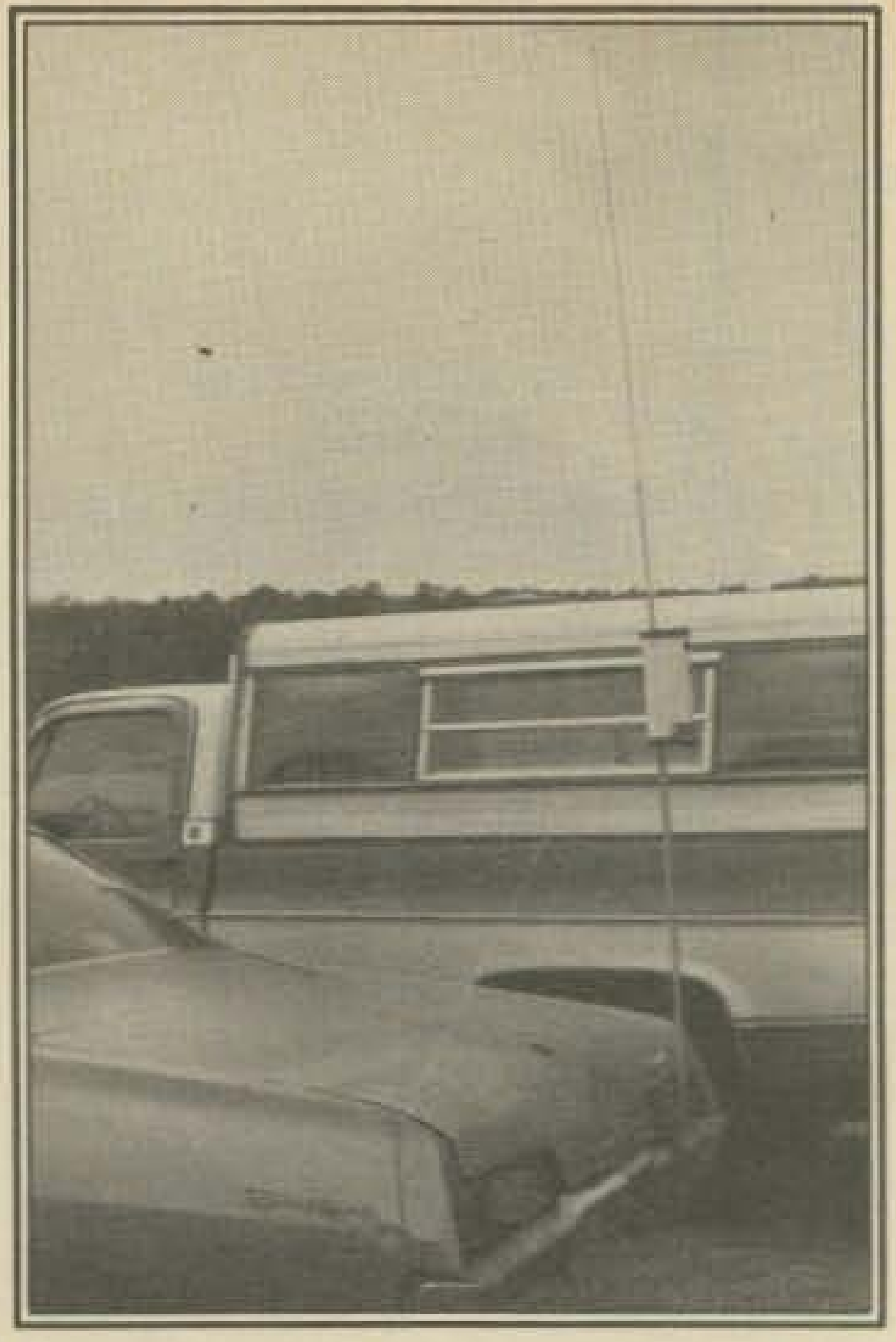
Base Loaded Multiband Verticals

We've said that the simple quarter-wave antenna is basically a one-band antenna. Nevertheless, one can easily load up a single 16-25′ vertical on all bands, 80-10 meters. The usual configuration is a vertical piece of tubing, used in conjunction with a base loading coil. By tapping the coil at appropriate points, the antenna can be roughly matched to 50-ohm coaxial cable on any band. This no-trap antenna must be manually adjusted when switching bands. Adjustment must be made at the antenna, not from the shack; bandswitching isn't automatic.

This type of antenna is an excellent compromise for all-band operation, especially for the budget-conscious amateur who can't erect separate verticals for each band, or who can't afford the cost of an all-band trap antenna. The antenna design lends itself to homebrew construction, since there are no mechanically challenging traps to build, weatherproof and install. It's also a good antenna for the space-limited amateur, since its overall length is normally under 25′. This length works out to a bit longer than 3/4-wavelength on 10 meters, chosen as the maximum length that will yield a low-angle radiation characteristic on the highest band to be used.

Fig. 2 shows electrical details of the base loaded multiband vertical. A tapped inductor, consisting of about 30 turns of 2-3″ diameter B&W or similar coil stock, makes up the loading coil. It is tapped from the top at the appropriate points so as to resonate on each band of interest; the clip is tapped down the coil as bands are changed. The center conductor of the coax is tapped up from the bottom of the coil for impedance matching purposes, or an r.f. transformer can be used to effect impedance transformation. The parallel capacitance shown in the figure, about 100 to 150 pf., may or may not be required, depending on the band in use and the length of the antenna. An s.w.r. bridge is recommended for adjustment. An antenna noise bridge may also be used for accurate resonance determination.

Low-low r.f. transformers such as this 500-watt unit by Palomar Engineers allow broadband matching to low-impedance antennas, such as short verticals and mobile whips. Small, high-efficiency package has switch-selected taps at 8, 12.5, 16, 22, 32, and 50 ohms. An r.f. ferrite toroid core is at the heart of the device. (Photo courtesy Palomar Engineers)

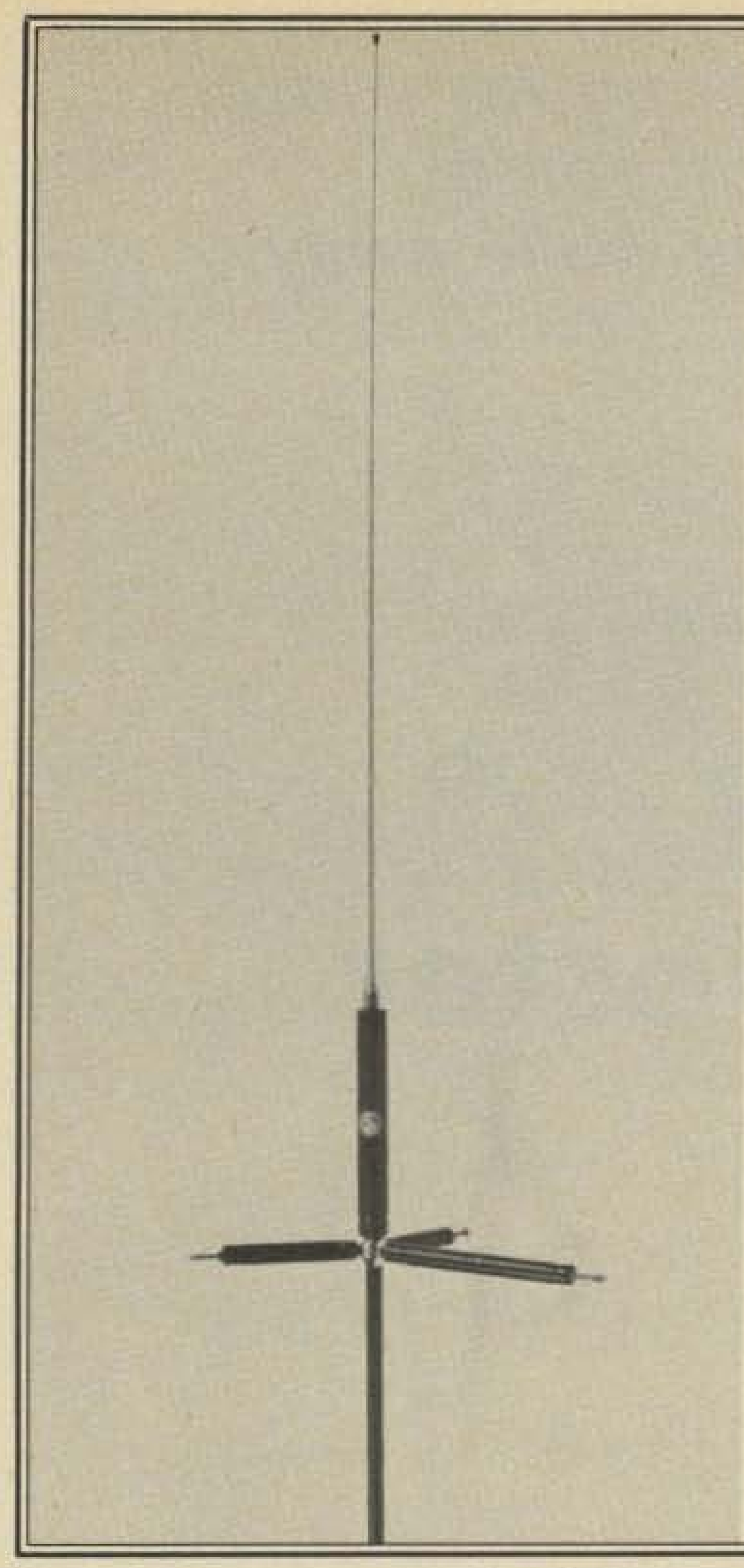


A tri-band mobile antenna by Swan features automatic operation on 20, 40, and 75 meters. After initial adjustments have been made, the antenna requires no changing of coils to change bands. Just flick the transceiver bandswitch. Operating bandwidth is 25 kHz on 75, 70 kHz on 40, and 90 kHz on 20 at the 2:1 s.w.r. points.

Mechanical details are simple. Two or three sections of 10′TV mast can be used to construct the antenna. The masts can be supported by a soda or beer bottle and guyed with nylon cord or rope if necessary. Another possibility is to side-mount the mast sections on a length of wood using heavy ceramic insulators. Since the loading coil is connected at the base, it doesn't interfere with the antenna's mechanical strength.

As with most verticals, the quality of the ground system is important, especially on the lower bands. The antenna can be fed as a ground plane or it can be ground mounted. However, if fed as a ground plane, separate, resonant radial sets are required for each band for good results. This becomes unwieldly, to say the least, especially on the lower bands. For this reason, I suggest installing the antenna on the ground and using a ground rod and radial system, as described last month. Resonant radials need not be used if the antenna is ground mounted.

What about performance? This type of multiband antenna can produce surprisingly good results despite its simplicity and relatively low cost. It's



Antenna of the Month

Unusual, multiple-resonant Swan mobile antenna covers 10, 15, and 20 meters and requires no coil change or readjustment after initial tuning; for additional band coverage, optional 160, 80, or 40 meter coils and top section can be added. The 200-watt p.e.p. mobile antenna features low s.w.r. at resonance; independent resonance adjustments on each band; wide bandwidth; and a low-wind-resistance profile. Its design also lends itself to trailer park, mobile home, camper, or apartment mounting schemes.

Besides the basic 3 lb. antenna base rod and 10/15/20 meter resonators, accessories include a base extender rod, telescopic top section (for 160/75/40 meter operation), and center loading coils required for 160, 80, and 40 meter work. (Photo courtesy Swan Electronics)

an especially attractive proposition for the Novice who wants to try his hand on *all* the h.f. bands open to him—80, 40, 15, and 10 meters. Two things to consider are that the antenna *must* be manually returned when switching bands, and that usable bandwidth (and s.w.r.) will be quite narrow on the lower bands. Also, the angle-of-radiation pattern will change for each band, since the antenna varies in relative length from band to band.

What about 160-meter operation? The short vertical can be used on the "top band" if a reasonably long radiator and large-enough loading coil are used. However, efficiency of the short base loaded vertical is low. And, while the vertical will produce good ground-wave signals on 160, it's been found that a horizontal antenna often outperforms the vertical at night when propagation is by ionospheric means. For these reasons, and to keep the loss-prone, high-current portion of the antenna as high as possible, bent or L-shaped antennas are favored for 160-meter operation. We'll cover these specialized antennas in a later column.

Next month we will conclude our discussion of verticals with trap-type verticals, matching and a bibliography of interesting articles concerned specifically with vertical antennas. See you then.

73, Karl, W8FX

a monthly feature by

KARL T. THURBER, JR., W8FX

Antennas

DESIGN, CONSTRUCTION, FACT, AND EVEN SOME FICTION

H.F. Verticals: Conclusion

Nontrap verticals are inexpensive antennas, whether purchased commercially or homebrewed from available materials. On the other hand, they are inconvenient to use if operation on several bands is desired, since the loading coil must be adjusted each time a band change is made. This makes rapid bandswitching impractical, especially if the antenna loading and matching network is buried under a foot of snow, or if the antenna is mounted high atop one's roof.

Parallel-tuned circuits, popularly known as traps, can be inserted in series with the radiating element at appropriate points to make each section work as a quarter-wavelength vertical or an "odd" multiple of a quarter wavelength. The traps work to effectively "cut" the antenna, electrically speaking, at the proper quarter-wavelength points. The traps present a very high impedance at or near resonance, acting as insulators at the end of each quarter-wavelength point on the appropriate bands.

For example, using the illustration of fig. 1, which shows a five-band trap vertical, the lowest section (that below the 10-meter trap) is physically a quarter-wavelength on 10 meters. The 10-meter trap effectively disconnects the upper section of the antenna so that they have no effect on 10-meter operation. To make the antenna work on 15, the lowest section, the 10-meter trap, and the section just below the 15-meter trap combine to form a quarter-wavelength on 15.

The traps and antenna sections continue in the same fashion to resonate on all bands down to 80 (or in some cases, 160) meters. For five-band operation, only *four* traps are required; a trap isn't required for the lowest band. On 80, the entire antenna and all the traps act to form an electrical quarter-wavelength.

As with base loaded multiband ver-

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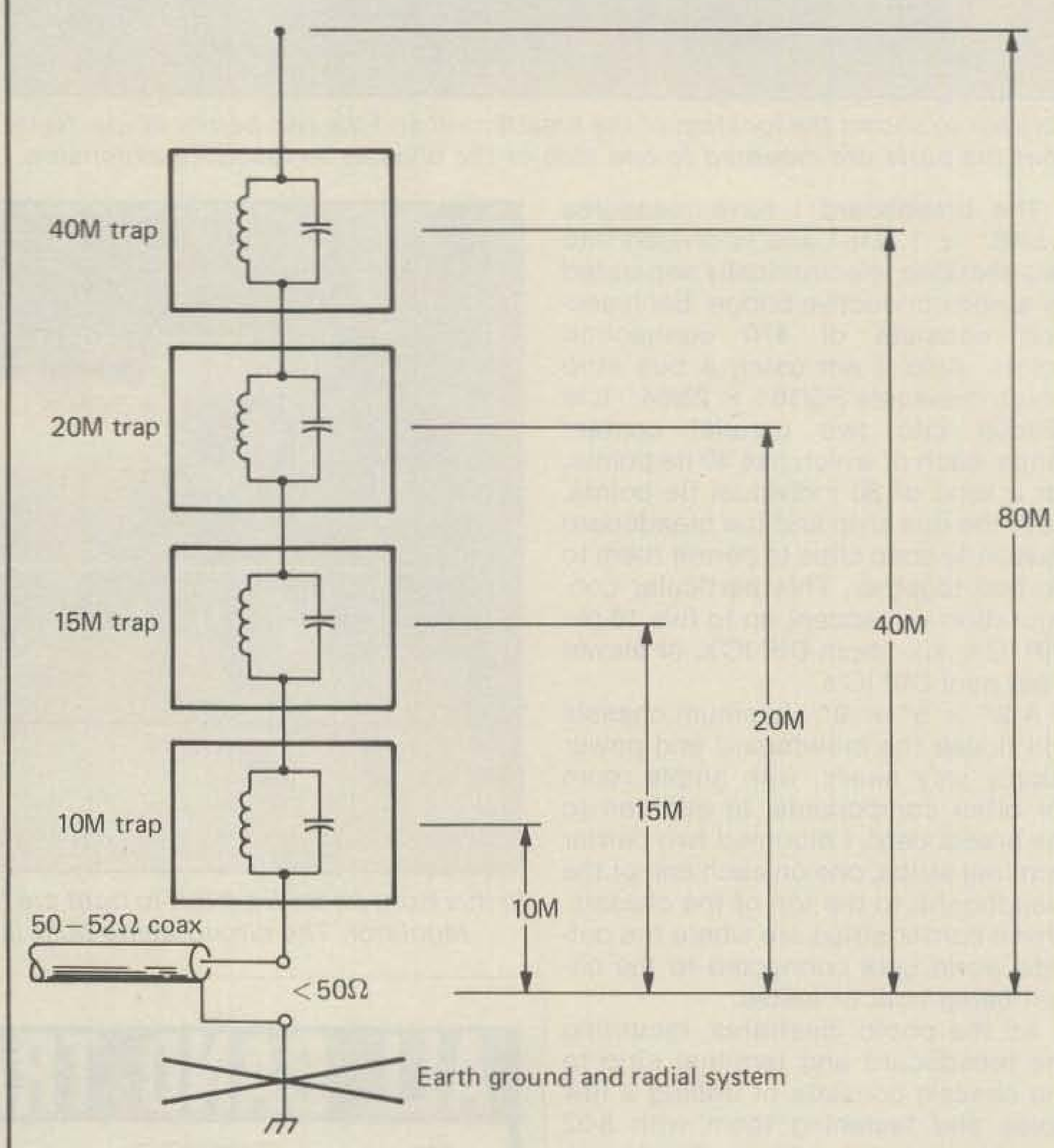


Fig. 1- A trap vertical antenna. The diagram represents a five-band multiband trap antenna.

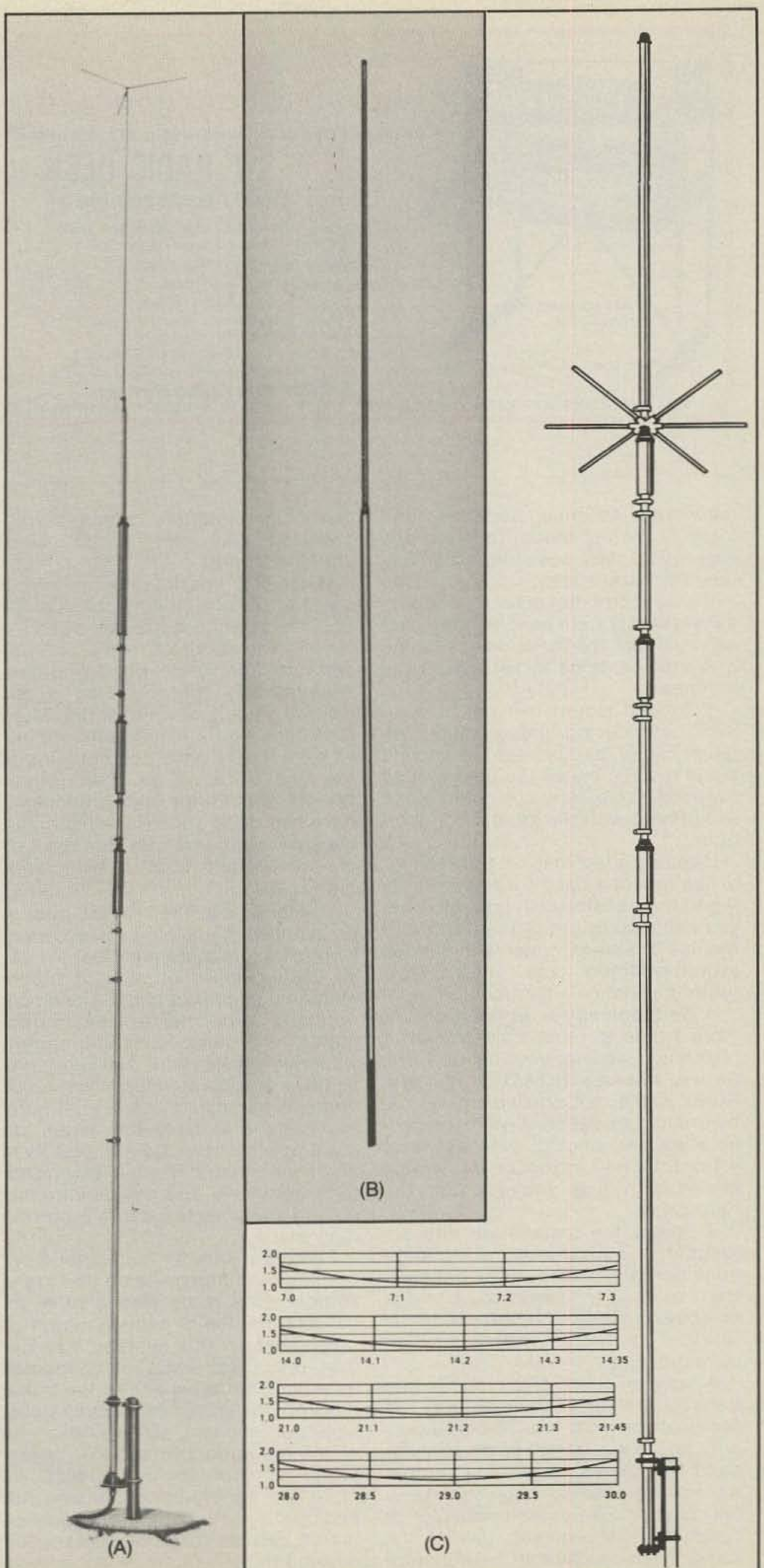
In the diagram above, the electrical length is adjusted by installing parallel-resonant traps at the proper points to effectively "cut" the antenna, electrically speaking, to quarter-wavelength dimensions. The traps offer high impedance at or near resonance, and therefore act as insulators for operation on a given band. The objective is to come up with an acceptable (not necessarily *perfect*) match to coax on all bands. In some cases, a base matching network or r.f. transformer is needed to effect a good match. Normally the antenna is ground mounted, unless radial sets are prepared for each band for above-ground installation.

ticals, trap antennas are usually much smaller than full-size verticals, typically about 18-25′ in length. To a large extent, the size is scaled down due to the loading effect of the traps, and the top-hats that are sometimes used.

The most efficient trap verticals use high-Q traps with large diameter coils for a favorable inductance-to-capacitance ratio. Many commercial five-band trap verticals have provision for using an optional 160-meter loading coil to allow operation on that band.

With short, high-Q trap verticals, the higher bands such as 10, 15, and 20 meters can be covered nicely from band edge to band edge. But usable bandwidth on the lower bands suffers so that either the 'phone or c.w. band segments must be selected for operation. A 100 kHz wide segment is about all one can expect on 80; 160 bandwidth will be especially narrow.

The purpose of the traps, of course, is to come up with an antenna that presents a resonant, matched load to the feedline. As is the case with all multiband antennas with which the author is familiar, the trap vertical represents a compromise; there is a great deal of interaction between the



(A) Hy-Gain 14AVQ/WB antenna covers 40-10 meters using three high-Q traps. The 18-lb. antenna shows SWR of 1.5:1 at resonance (or less) on all bands, if installed in accordance with the manufacturer's instructions. Antenna can be mounted on a mast up to 1-5/8" in diameter. (Photo courtesy Hy-Gain Electronics)

(B) Half-wave coaxial antenna is essentially a dipole stood on its end. The omnidirectional antenna requires no radials and is independent of mounting location. The Radio Shack 27 MHz CB antenna is shown here; the author has used this low-angle radiator on 10 meters with good DX results. (Photo courtesy Radio Shack)

(C) Representative compact trap vertical is this Hustler 4-BTV that covers 10 through 40 meters with an option or adding a 75-meter resonator. The 21′5" antenna weighs 15 lbs., boasts 1.15 to 1 s.w.r. at resonance (or better) and 1.6 to 1 (or better) at band edges. Antenna is fed with 50-ohm coax and handles full legal power levels. Wind loading is specified as 29 lbs. at 70 mph. Antenna may be ground or tower mounted. Manufacturer's typical s.w.r. curves are shown below.

individual antenna sections and traps. A perfect match on each and every band isn't possible, especially near the band edges.

It's no secret that antenna performance will vary from band to band. You can minimize the variations by taking a few precautions in setting up the antenna:

1. Ground mount it if possible, to avoid introducing unpredictable effects cause by the use of ground plane radials. Install the best ground system you can. And don't hesitate to experiment with the ground configuration.

2. Install a low-loss r.f. transformer at the antenna base for easy matching to the transmission line. After all, you can't easily get to the traps, and the use of a transformer with various switch-selected taps allows fine-tooth impedance adjustment.

3. Be prepared for at least one or more bands to stubbornly present a high s.w.r., despite your best efforts. So use low-loss RG-8/U or the new RG-8X cable, not small-diameter cables such as RG-58/U. With reasonable feedline lengths, even s.w.r.s of 4:1 or 5:1 won't introduce intolerable losses providing you're using the right cable.

4. Follow the installation and adjustment instructions. Anticipate considerable interaction between trap sections, and use an s.w.r. bridge or antenna noise bridge for antenna tuneup. Trap adjustment is an iterative process.

A special point: Many solid-state transceivers and transmitters are designed to work into 50-ohm loads *only*, so if s.w.r. is high on a particular band or bands, achieving proper transmitter loading may become a real problem. An antenna coupler or tuner may be required. Use of the tuner is also desirable to minimize harmonic radiation, which is aggravated whenever a multi-band antenna is used.

While it's possible to build your own trap vertical, the mechanical difficulties occasioned by the traps are beyond the reach of many, and perhaps most amateurs. For this reason, commercially manufactured antennas are usually one's best bet. Many amateurs who are fortunate enough to have a very high tree standing at the right location on their property—one with sturdy, high branches—have had good success using homebrew *wire* trap verticals that are simply suspended from a sufficiently high branch.

Matchmaking. The vertical, even in its simplest single-band, ¼-wave version, presents a problem that the basic dipole does not: that of proper matching to coaxial cable. The dipole normally presents a near-perfect match to popular 70-75 ohm cables, whereas the vertical typically presents a feedpoint impedance of 35 ohms, sometimes much less. If nothing is done to ease the match, an s.w.r. of other than 1:1 will exist even at resonance, and if cable lengths are long, additional loss will be introduced and transmitter loading problems may ensue.

There are several traditional ways to match the transmission line to the vertical. One is by means of a so-called shunt-fed or gamma match arrangement. In this system, a rod of 0.04 to 0.05-wavelength is connected in series with a capacitor; the transmission line center conductor is connected at one end, and the other end of the rod is connected at an appropriate point on the mast, which is grounded. By adjusting the capacitor and/or the rod length, an impedance match can be obtained. (Details are covered in the various antenna handbooks and won't be repeated here.)

Another method is to use a series of coax cable section to perform the impedance transformation. One possibility is to insert a short length of 70-ohm cable a formula-determined distance back from the feedpoint of a vertical fed with 50-ohm coax. Another is to use 70-75 ohm coax as the transmission line, inserting a ¼-wavelength segment of 50-ohm cable at the feedpoint to bring the 35-ohm impedance up to about 75 ohms. More alternatives are possible using series sections: refer to Frank Regier's excellent article on series impedance matching in July 78 *QST* (see bibliography). If you go the series-matching route, realize that when working with coax sections, you must use their *equivalent* electrical length, which works out to less that the free-space wavelength calculations. Be sure the formulas you use to determine the length of the coax section take into account the cable's *velocity factor.*

We get into trouble when we want to use the antenna on more than one band, since the gamma match and series line dimensions hold for but *one* band. It's especially difficult when the antenna is considerably shortened, since the radiation resistance can be quite low and difficult to match to any available transmission line.

An alternative is to use an **r.f. transformer.** Although it will not "tune out" reactance (the antenna should be resonant), it will readily transform the low feedpoint radiation resistance to work into 50-ohm cables. Several firms market low-loss r.f. transformers, including SST, Swan, and Palomar Engineers; these have a number of impedance taps which cover the range of impedances likely to be encountered, from about 5 ohms up. Once initial tap adjustment is set, little further attention is required, providing the antenna is kept at or near resonance. Shortened, loaded or trap-type verticals may require coil readjustment to keep the system close to resonance and the feedpoint impedance under control.

Summary

What can we conclude? The judgment on h.f. verticals is left up to you. In my book, however, if their basic characteristics and operating limitations are understood, they can make excellent, relatively low cost antennas for the DX'er. The vertical is especially attractive as an unobtrusive, easily installed and portable antenna that allows effective multiband operation on a small lot.

Next month, we will break with ver-

ticals to cover a somewhat neglected though simple and effective all-band antenna: the horizontal flattop fed with tuned feeders. See you then.

73, Karl, W8FX

Bibliography

Source material and an extended discussion of the antenna topics covered can be found in the references listed below:

1. Greenberg, Herb, W2EEJ. "10 M Folded Ground-Plane," *CQ,* August 1956.
2. Griffith, B.W., W5CSU. "The Truth About the Vertical Antenna," *QST,* May 1952.
3. McCoy, Lewis G., W1ICP. "Choosing an Antenna," *QST,* January 1962.
4. McCoy, Lewis G., W1ICP. "Some Plain Facts About Multiband Antennas," *QST,* Sept 1972.
5. McLaughlin, Norman R., W4GJR. "Facts About Vertical Radiators," *CQ,* November 1959.
6. Regier, Frank A., OD5CG. "Series-Section Transmission-Line Impedance Matching," *QST,* July 1978.
7. Rennaker, Russ, W9CRC. "A 'Pipe Organ' Multiband Vertical Antenna," *CQ,* January 1979.
8. Schulz, Walter, K3OQF. "Designing a Vertical Antenna," *QST,* September 1978.
9. Sevick, Jerry, W2FMI. "Short Ground-Radial Systems for Short Verticals," *QST,* April 1978.
10. Stanley, John O., K4ERO/HC1. "Optimum Ground Systems for Vertical Antennas," *QST,* December 1976.
11. Anderson, Marian, WB1FSB. "Build This Novice Four-Band Vertical." *QST*, June 1978.
12. Hale, Kayla, W1EMV. "Expanding Your Mobile Mobility," *Ham Radio Horizons*, May 1978.
13. Price, Gary H., W6IRA. "Base Loading a Simple Vertical Antenna for Two-Band Use," *CQ*, June 1978.
14. Reynolds, Dr. Donald K., K7DBA. "The Black Art of Antenna Design," *73*, November 1979.
15. Sevick, Jerry, W1FMI. "The Constant Impedance Trap Vertical," *QST,* March 1974.
16. Taylor, L. I., W1VLK. "Vertical Multiband Antennas," *QST*, May 1955.
17. Thurber, Karl T., Jr., W8FX. "Traps and Trap Antennas," *Ham Radio*, August 1979.

CQ DX Tip

—If you called CQ-DX and more than one station replied, you called too long. —*W4MB*

a monthly feature by
KARL T. THURBER, JR., W8FX

Antennas

DESIGN, CONSTRUCTION, FACT, AND EVEN SOME FICTION

More On Dipoles: Multiband Antennas With Tuned Feeders

In this month's column, author W8FX points out that coaxial cable isn't sacred as transmission lines go. There's still room for parallel feeders when it comes to easily constructed and inexpensive multiband antennas. Read on for theory and construction information on some simple antennas that may have slipped from memory.
—K2EEK

A good antenna is a good antenna, regardless of whether it is fed with coaxial cable, single-conductor line, twinlead, hardline, open-wire feeders, or any other transmission line one can dream up. True, the use of various kinds of feedlines *does* have an impact on antenna operation, but it's mostly on the type of coupling required for proper loading and matching, and to a secondary extent on line loss.

At least since the early fifties, coaxial cable has seemed to be the best and, to many, the "only" way to feed antennas. This is because the cable is easily handled, it can be snaked through a small hole in the house or a window casing, it closely matches the common dipole's feedpoint impedance, and a number of other factors. Coax is also popular because it radiates very little; it provides a convenient vehicle for inserting various devices in the antenna circuit such as s.w.r. bridges, transmit/receive switches and low-pass filters.

Some of these "advantages" pale when we consider antennas other than the simple single-band dipole or beam; the antenna's low feedpoint impedance holds only for the fundamental frequency (or odd harmonics thereof). When coax is used to feed an antenna that isn't operating near resonance—such as an 80-meter dipole used on 40 meters—we run into trouble from the high s.w.r. and the resultant cable loss and transmitter matching problems.

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Two once popular but sometimes forgotten antenna types are useful to the beginner and old-timer alike who want to operate over a wide range of frequencies, not just a single band or two. These are the **Zepp** and the **centerfed multibander**; we'll cover them both.

A Word On Tuned Feeders

The purpose of the transmission line is to provide an efficient path for r.f. to travel from the transmitter to the antenna. The line should not radiate of itself, but rather act as a "conduit."

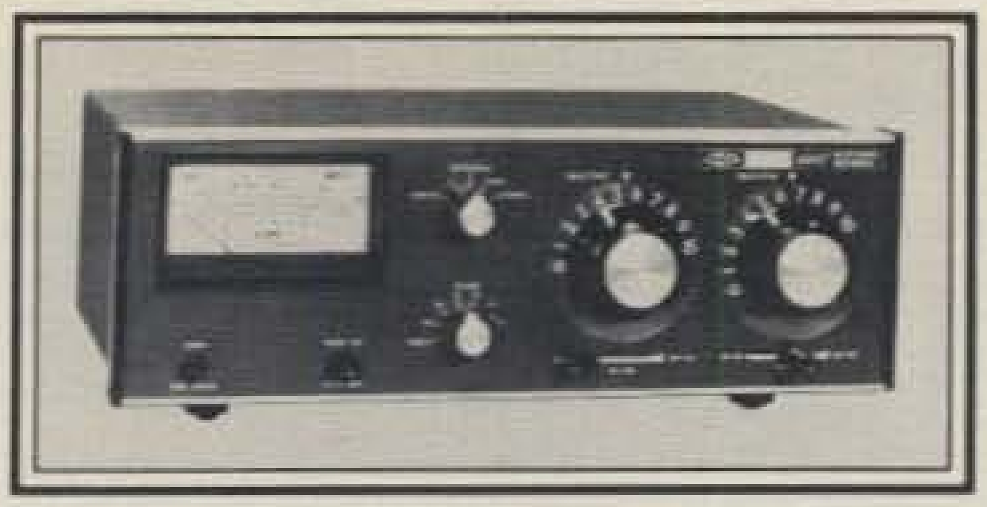
There are two common types of feed lines used by amateurs—coaxial cable and parallel-conductor line (including open-wire and twin-lead). The most popular by far is coaxial cable, which comes in several impedance designations and which is very convenient to use and easy to handle. Coax is perfectly suited to feeding most single-band antennas, such as ordinary dipoles, verticals and beams, in addition to low-impedance multiband antennas such as trap and multiple dipoles.

Coaxial cable presumes a good impedance match at the antenna. When a mismatch exists, standing waves are produced and line losses increase with higher s.w.r.s. Since the impedance of the multiband dipole will vary considerably from band to band and there is no way to control the feedpoint impedance, coax just isn't suitable for use as a feedline. It *must* be operated in the matched or so-called "untuned" or "flat" mode.

On the other hand, parallel-conductor transmission lines—especially those of the low-loss open-wire type—can be operated almost without regard to s.w.r.; this is because there is very little inherent loss in the line. Thus, the actual feedpoint impedance of the antenna is not too important, since when the line loss is low we don't have to be overly concerned with line matching. Multiband operation is a "natural" for tuned feeder systems: an antenna cut for a relatively low frequency band (say, 80 meters) is operated on higher frequency bands by "tuning" the feeders to the harmonic frequencies, thus the term "tuned feeders."

Tuned-feeder arrangements are most commonly used with center-fed dipoles and end-fed Zepps; these are the two types with which we will be most concerned. However, tuned feeders have been used to feed vertical and vertical ground-plane antennas, as well as verticals that are half-horizontal (L-shaped), slanters and slopers. And, tuned-feeder schemes have been put to good use in connection with several types of beam antenna designs, including some wire

Multiband antennas using tuned feeders inherently have high s.w.r.s, though this is not unacceptable since the transmission line used is normally of the low-loss kind. Impedance transformation to coax is made at the antenna coupler, and a high-quality h.f. wattmeter/s.w.r. bridge is used to make adjustments to the coupler. A dual-reading (forward and reflected power) meter is best, since it allows one to catch any erroneous coupler tuning settings that may reduce forward power while showing low s.w.r. Heath unit shown here handles 2000 watts p.e.p. in two power ranges from 1.8 to 30 MHz. (Photo courtesy Heath Company)



Of interest to the 160-meter buff, this Drake MN7 matching network has an internal feed switching arrangement that allows a conventional 135-foot balanced-line fed doublet to be driven as an inverted "L". The "L" is fed through a 4:1 impedance-matching transformer, with the other half of the antenna acting as a counterpoise. (Photo courtesy R.L. Drake Co.)

beams used on harmonics and multiband V-beams.

Used in conjunction with a wide-range antenna tuner (transmatch), antenna length as well as feeder length isn't too critical. The antenna itself is usually cut for one-half wavelength at the lowest frequency to be used, though good results can be had with flattops as short as one-quarter wavelength, or with half-wave flattops bent to accommodate the available space. The feeder length can be whatever happens to result in the shortest run from antenna feedpoint to hamshack, though certain feeder lengths can give rise to problems with parallel currents flowing, with resultant radiation from the feeders and possible loading problems. If the feedline does radiate, no great harm is done since energy isn't truly wasted: rather, the radiation pattern is distorted. Choosing a feeder run that's along the lines suggested should keep you out of trouble on this score.

A final point: For best results using tuned-feeder antennas, use open-wire line, not 300-ohm solid dielectric cable, such as TV twinlead. Even when using heavy-duty, transmitting-type lines, the losses in such cases will be excessive on those bands where the antenna operates with a high s.w.r. Also, most solid-dielectric cables are weather sensitive, so that changes in climatic conditions (ice, snow, rain, etc.) will cause changes in line characteristics and erratic loading conditions. Stick to *open-wire* lines: attenuation at 10 meters is on the order of 0.1 dB per 100 feet when perfectly matched, whereas RG-8/U clocks out at about 1.0 dB, RG-11/U at 1.15 dB and RG-58/U a whopping 2.5 dB. Ordinary TV twinlead shows about 0.6 dB, but losses rise with high s.w.r. and when the line is wet. "Ladder line" of the 470-ohm type distributed by Dentron Radio and others is a fair compromise that is easier to handle than open-wire line but has only slightly higher attenuation.

In any case, the feeders should be handled with care. Feeder spacing should be kept constant over the line length, the line should be kept well away from other conductors that might be coupled to it, and sharp bends should be avoided. Special care should be taken where the line enters the hamshack. An insulated TV-type feedthrough tube can be used, with a short length of twinlead installed where the feedline passes through the wall. The line should be protected against lightning discharges, as described later.

Enter The Zepp

The "Zepp" or *Zeppelin* antenna is one of the oldest in amateur radio, dating from the times of the gas-filled airships bearing the same name. The classic Zepp consisted of a resonant half-wave antenna that was folded back on itself and suspended below the airship. It was usually fed through a ¼-wave line. In amateur use, the tuned feeders run from the "shack" to one end of the antenna. One side of the feedline is connected to the antenna flattop, while the other side of the feedline is not connected at all except to the end insulators.

The Zepp is a very practical antenna and one that's convenient to use, particularly if the shack happens to be physically located near one of the end supports of the span. The skyhook becomes a *voltage-fed* antenna, since the radiating portion is some multiple of a half-wavelength and therefore there is always a high voltage present where the feeder attaches to the flattop. This is in contrast to the centerfed dipole antenna, where a low impedance exists at the feedpoint at the resonant frequency and on odd harmonics.

An end-fed Zepp cut for the lowest frequency to be used should give a good account of itself on the fundamental and on higher frequencies. The length of the Zepp should be cut about 5% longer than the free-space half-wavelength because of so-called "end effects" which tend to electrically shorten the antenna's effective length. The formula can be used to calculate the length.

$$L\text{ (feet)} = \frac{492}{f(\text{MHz})}$$

For operation on 80 through 10 meters, a flattop of 135 feet should be right. If 40 is the lowest band to be used, 67 feet should do the trick. (If you can only install a 67′ flattop and want to operate on 80, you may want to consider tying the two feeders together at the shack and feeding the entire system against ground as a random-wire.)

Since the currents in the two feeder wires do not exactly balance in the Zepp, there is some radiation from the line, though to a certain extent the fields of the two conductors cancel out. Any convenient feedline length can be used. However, to minimize parallel currents which would increase line radiation, use a feeder length that doesn't show resonance effects on any band to be used; a length of either 44 or 77 feet is a good one to work with. The radiation pattern of the Zepp operated on harmonics tends to the cloverleaf, though the *actual* pattern

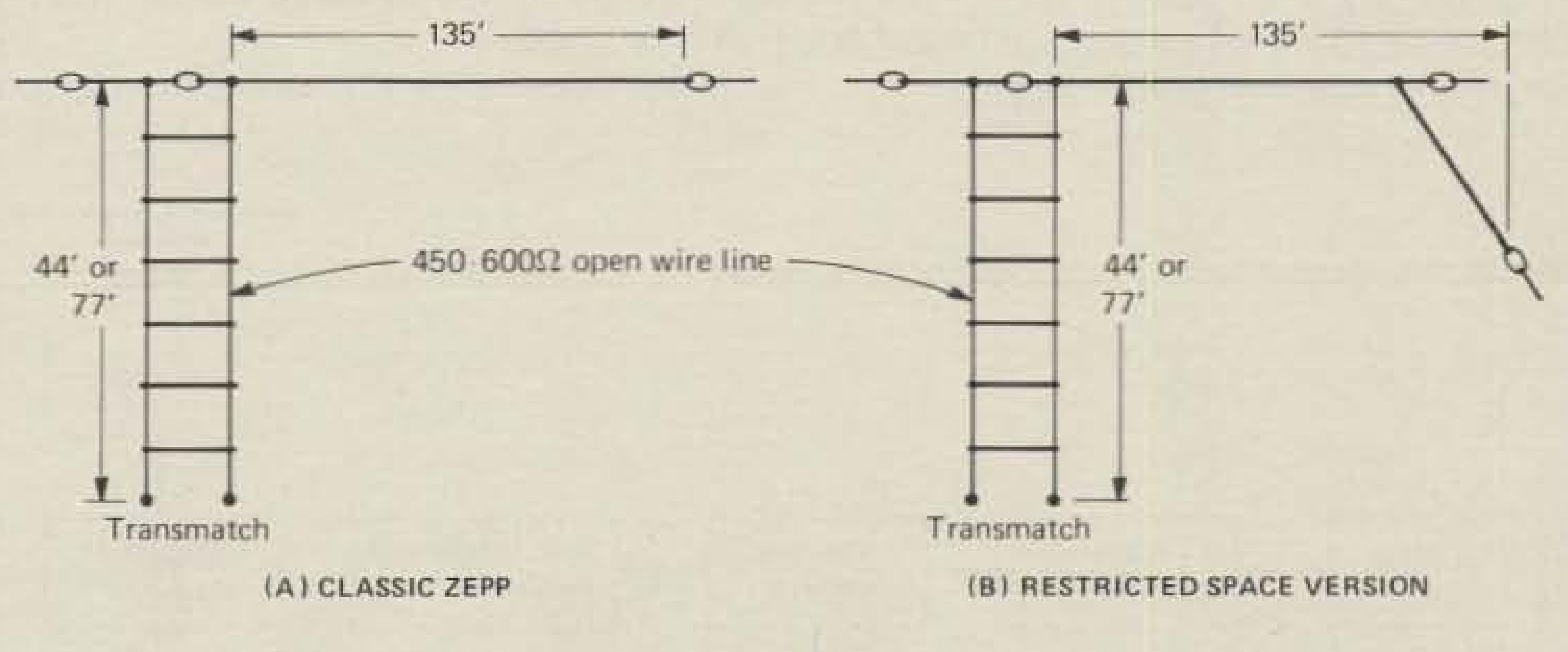


Fig. 1– Zepp antenna configurations.

The end-fed Zepp at (a) is a popular contemporary version of a very old antenna type. The antenna is usually cut for operation as a half-wavelength at the lowest frequency band to be used and the feeders "tuned" to work as a resonant system on the higher bands. For operation on 80-10 meters, a flattop of about 135′ should do the trick. An open-wire feedline of any convenient length can be used, but a length of about 44′ or 77′ should minimize the possibility of "awkward" loading situations at the antenna tuner or coupler.

If room for a full-size flattop isn't available, the ends can be bent around as at (b), with some risk of undesired directivity effects. The ends can even be bent down with resultant mixed polarization signal characteristics.

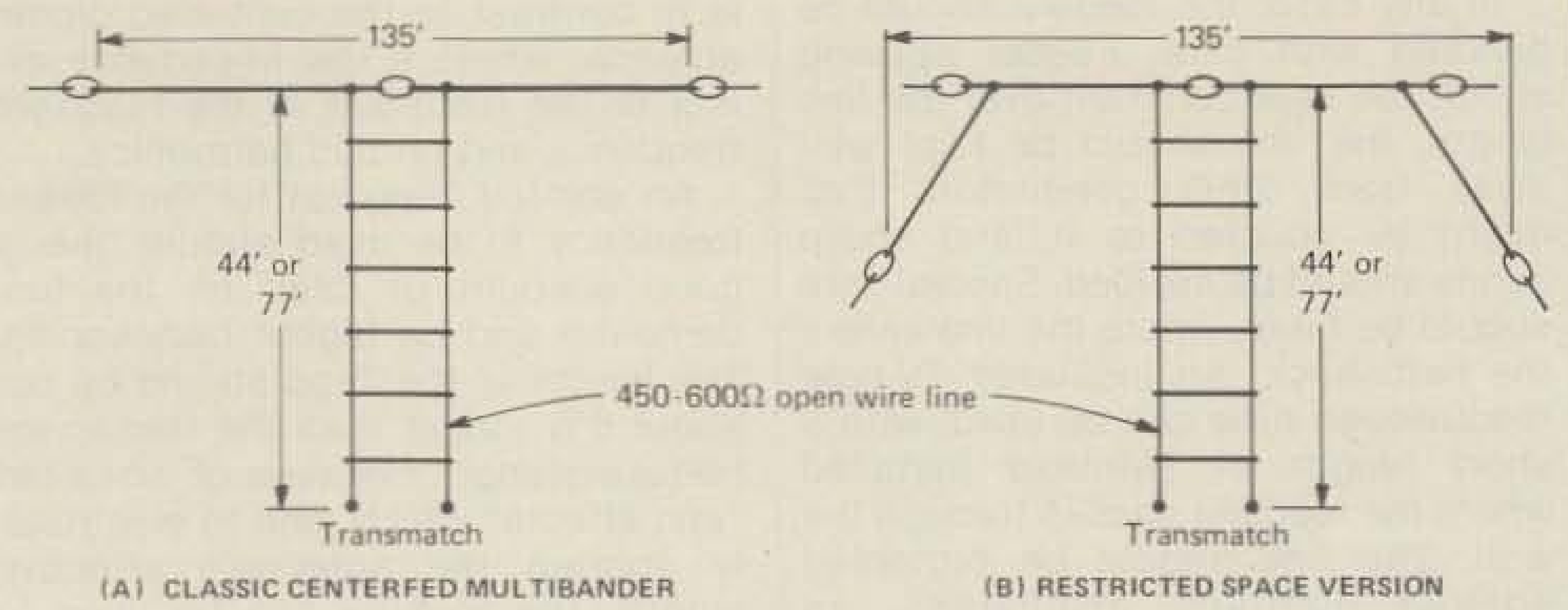


Fig. 2- Center fed antenna configurations.

Shown at (a) is a simple, practical all-band (80-10 meter) antenna designed for use with tuned feeders and an antenna coupler or Transmatch. The antenna shown is basically an 80-meter tuned doublet operated on harmonics for the higher frequency bands. Installed high and in the clear, it's probably the best all-round antenna for multiband use. A length of 135′ represents a good compromise, and feeder lengths of 44′ or 77′ are popular, though almost any feeder length can be used.

If space is a problem, the flattop can be less than ½ wavelength on the lowest band with little decrease in efficiency until the straightaway length reaches ¼ wavelength. If loading becomes a problem when this is done, try increasing or decreasing feedline length.

The flattop can be bent around, horizontally or vertically, if necessary, into almost any shape to fit available real estate, with some loss of effectiveness. Many variations can be used, but try to keep the antenna symmetrical to keep the system in balance. The sketch at (b) shows a typical restricted space version.

will be distorted by feedline radiation. Fig. 1 shows typical end-fed Zepp configurations.

Centerfed Multibanders

For simplicity, efficiency and economy, this is a hard antenna to beat. Though the single-wire may be a shade *simpler*, the centerfed antenna is much less critical as far as matching, tuneup and loading go. In fact, it's probably the best single, all-round h.f. antenna you can erect.

Sometimes known as the "tuned doublet," this kind of antenna is desirable because it's symmetrical. Center feed is much more desirable than end feed for a number of other reasons, including the fact that it usually produces a lower s.w.r. on the transmission line. Even with center feed, the s.w.r. mismatch may be 8 to 1 or more, but this doesn't matter much when low-loss open-wire transmission line is used.

The length of the antenna flattop isn't critical, though some combinations of antenna length and feeder will induce parallel-current flow. As with the Zepp, a flattop length of about 135 feet should produce good results on 80 through 10 meters. Again, feeder lengths of about 44 or 77 feet should minimize possible loading problems. A shorter flattop length can also be used; a 67-foot span and either a 44-foot or 77-foot feedline are popular combinations for all-band work. The antenna span can be reduced but efficiency starts to take a dive. For best results, the antenna should be installed as high and in the clear as possible, with the feedline brought away from the antenna at *right angles*.

If you want to improve the centerfed multibander's balance, you can do so by inserting an r.f. ammeter in each side of the feedline (or moving a single ammeter from one feedline wire to the other), making slight adjustments to antenna length until current readings are the same in both legs. Bear in mind that unsymmetrical placement of the antenna with respect to nearby conductors such as power lines, telephone wires, etc., can cause inherent unbalance.

The center-fed multiband dipole especially lends itself to limited space situations. The ends can be bent around (within reason), and it can be erected in Vee, inverted Vee, and sloper configurations. At least one manufacturer, Dentron Radio Co. Inc. (2100 Enterprise Pkwy., Twinsburg, OH 44087), sells a factory-assembled antenna of this type designed for 160-10 meter operation.

See fig. 2 for some center-fed multiband configurations.

Tuning, Loading, Matching And Harmonics

As indicated, the tuned-feeder arrangement requires the use of an antenna tuner or coupler in order to work into the low-impedance pi-network output of most contemporary tube and solid-state rigs. While practically any type of tuner designed to handle balanced, parallel-conductor lines will do, a wide-range design will practically eliminate loading problems caused by exceptionally high or low impedances that can be presented to the transmitter by oddball feeder or flattop dimensions. Highly recommended are tuners based on the so-called "ultimate transmatch" design pioneered by ARRL staffer Lew McCoy several years ago. Tuner designs based on his original invention are found in the *Handbook*. Most of the fancier commercial tuner models are of this type or close cousins, and can handle practically any matching condition that one might encounter—series tuning

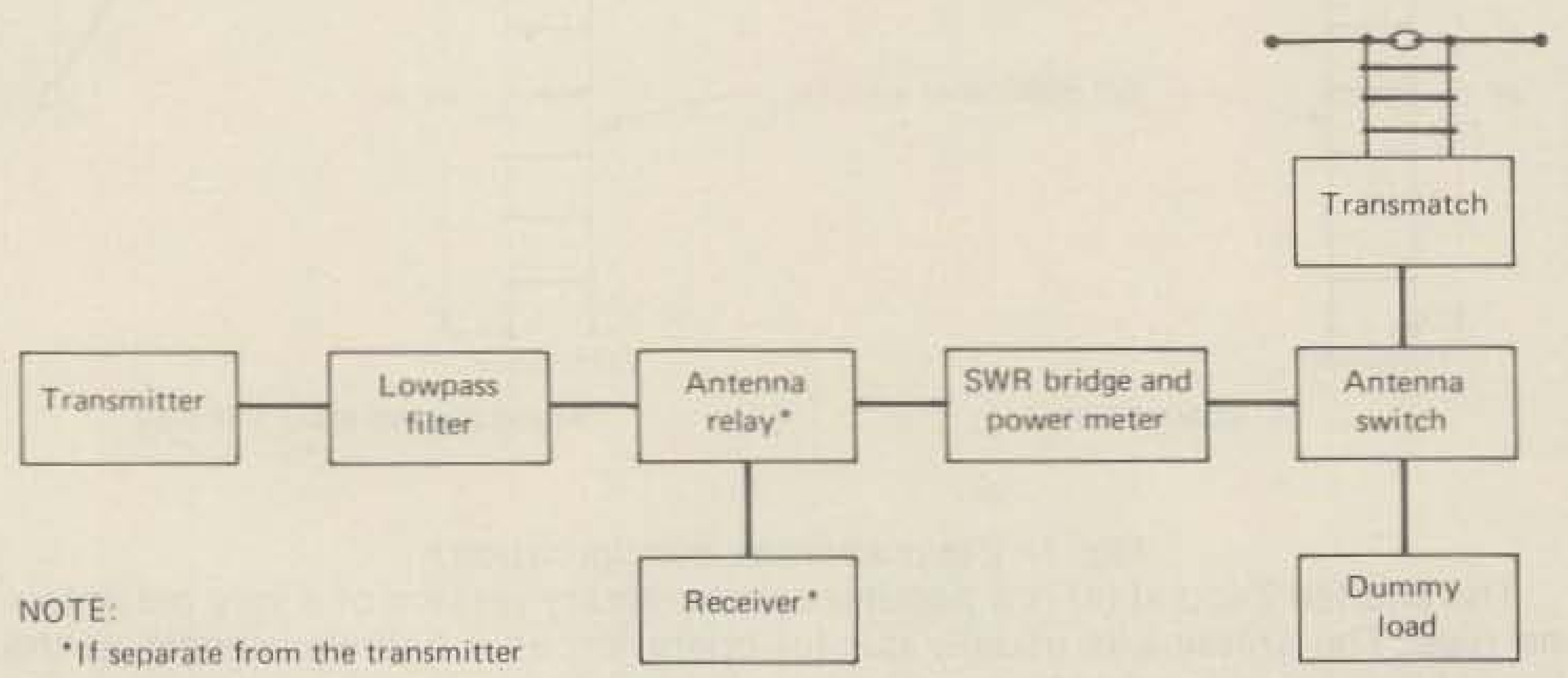


Fig. 3- Multiband antenna feeding arrangements.

The diagram above shows the suggested order in which the various components are connected together in the multiband antenna system fed into the tuned feeders. If a transceiver is used, the antenna relay is eliminated since transmit/receive switching is accomplished internally. Normally, 50-ohm coaxial cable is used to tie the units together, though 70/75-ohm cable may also be used

for low impedances and parallel tuning for high impedances. For good results with tuned-feeders, look for a coupler that will work over the range of at least 25 to 1200 ohms. One containing a built-in balun and a dual-reading (forward and reflected power) wattmeter is an especially useful accessory.

A problem encountered when using any multiband antenna system, including the center-fed multiband dipole and end-fed Zepp, is that of harmonic radiation. All multiband antennas tend to accept power at harmonic frequencies. Normally, harmonic suppression is adequate in modern transmitters, though use of a multiband antenna can cause radiated harmonics to approach the ragged edge of acceptability. However, the transmatch, when properly adjusted, usually eliminates any possibility of excessive harmonic radiation and also has the side benefits of improving receiver-to-antenna matching and reducing image and spurious signal reception.

In those few instances where using a multiband antenna in conjunction with an older transmitter not having adequate harmonic suppression results in harmonics of the fundamental frequency being radiated (with FCC "pink ticket" violation notices a possible result), a series half-wave filter may be indicated. A filter can be homebrewed from designs in the reference handbooks, or, a commercial filter can be found from among Barker and Williamson's line. Several models are available that have lowpass cutoff frequencies just above the highest band to be used.

For TVI reduction, a standard lowpass filter should be installed in the coax line between transmitter and transmatch.

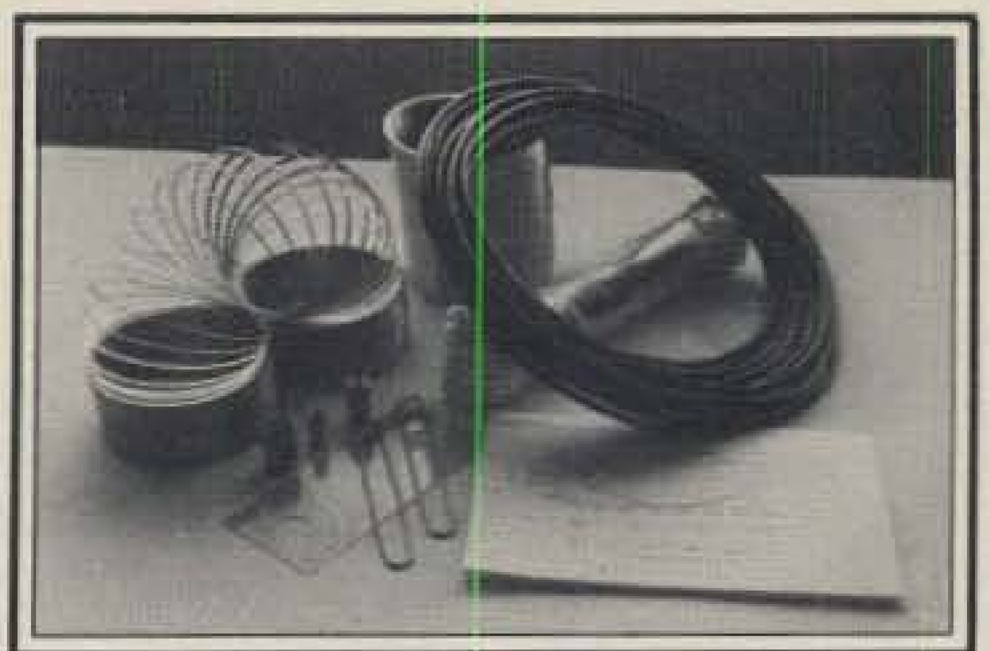
Fig. 3 shows suggested arrangements.

Lightning Protection

When working with dipoles fed with coaxial cable, we tend to assume that lightning protection is automatically taken care of since the cable's heavy braid is at ground potential. However, protection is by no means automatic when using coax, and it's especially questionable when using parallel-conductor feedlines which are high above ground potential and effectively offer no protection to lightning strikes or even static discharges.

Lightning protection is a "must" for either twinlead or open-wire line. Either an arrestor can be used, preferably at the point the feeders enter the hamshack, or the lead-in can be disconnected from the equipment and grounded whenever the rig isn't in use. The arrestor or grounding bar must be connected to a suitable

Antenna Of The Month: The Slinky Dipole Antenna

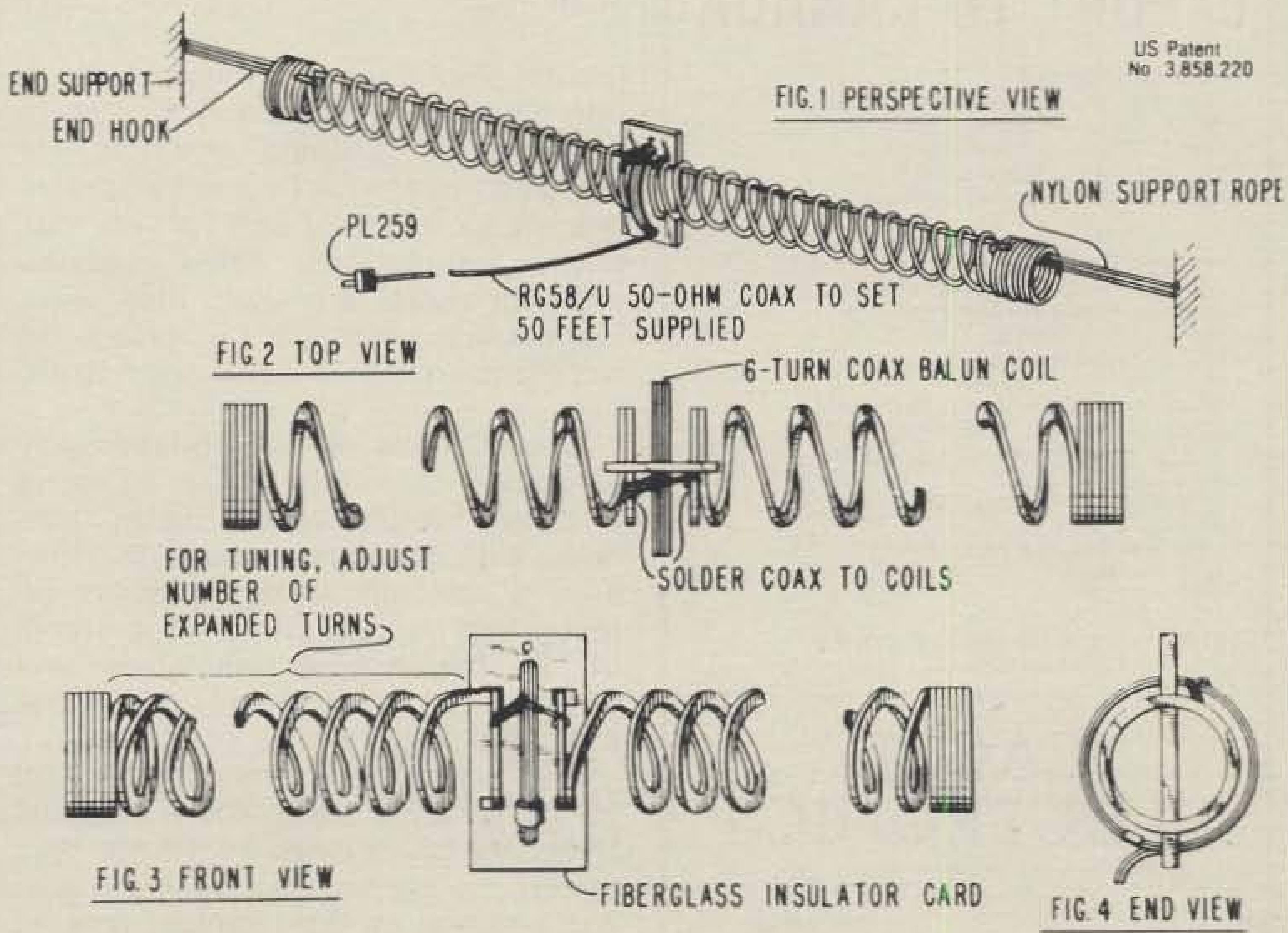


The "Slinky" dipole is a restricted-space, variable-length, electrically shortened h.f. antenna that can be adjusted for use anywhere within the range 3.5 MHz to 30 MHz, including the new WARC bands and the popular MARS, CAP and SW bands. It achieves good single-band impedance match to 50-ohm coax by means of the helical inductive loading provided by the spring structure; its efficiency approaches that of a full-size dipole when properly installed. When adjusted for resonance, the s.w.r for the antenna should be less than 2.5:1 over the 80 meter band and less than 1.8:1 over the 40- and 20 meter bands, with comparable figures on the higher frequencies. A built-in coaxial balun is included, along with the two special Slinky coils, center insulator card, nylon cord, end hooks, 50 feet RG-58/U coax, coaxial connector, and instruction sheet.

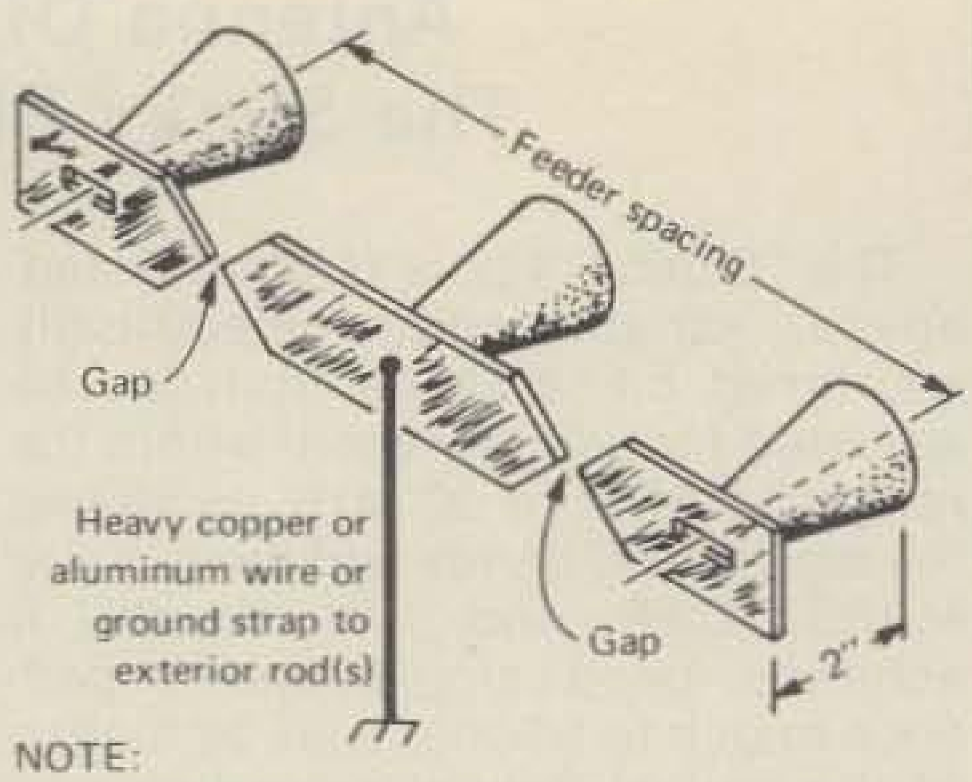
The story behind the antenna's development is an interesting one. The Slinky was invented by Richard Lodwig, W2KK and Sidney Arnow, WA2OPN, in 1973. They approached a large (covert) government agency with the idea, shortly thereafter. They liked the idea, but didn't want to pay for the development effort. As a result, the inventors did the engineering themselves, then sold units to various government agencies. Finally, they decided to try the antenna in the commercial and amateur markets, and it caught on. Today, two versions are available, the amateur version (no. 80-10) and the s.w.l. version (SWL-1), as well as commercial designs. All are basically the same antenna.

The photo shows the main components of the Slinky package. The table shows comparative standard dipole and Slinky lengths, and the diagram shows details of the antenna's construction. The antenna is sold by Teletron Corp., Suite 300, Box 84, Kings Park, N.Y. 11754.

BAND	STANDARD DIPOLE LENGTH		SLINKY LENGTH	
Meters	Ft.	Meters	Ft.	Meters
80/75	133	41	***24***	***7.3***
40	67	20	***12***	***3.6***
20	33	10	***6***	***1.8***
15	22	7	***6***	***1.8***
10	17	5	***6***	***1.8***



Drawing showing details of the SLINKY Dipole Antenna



NOTE:

Adapted from W4ZG's lightning arrester design appearing in the July 1955 issue of *QST*. Also see the current edition of the ARRL *Antenna Book*, p. 271.

Fig. 4– Parallel conductor lightning arrester.

Illustrated is an easy-to-make outdoor lightning arrestor for use with parallel-conductor lines; it is especially suited for use with *open-wire* lines. The objective is for lightning discharges to "shoot the gap" and be passed harmlessly into the ground.

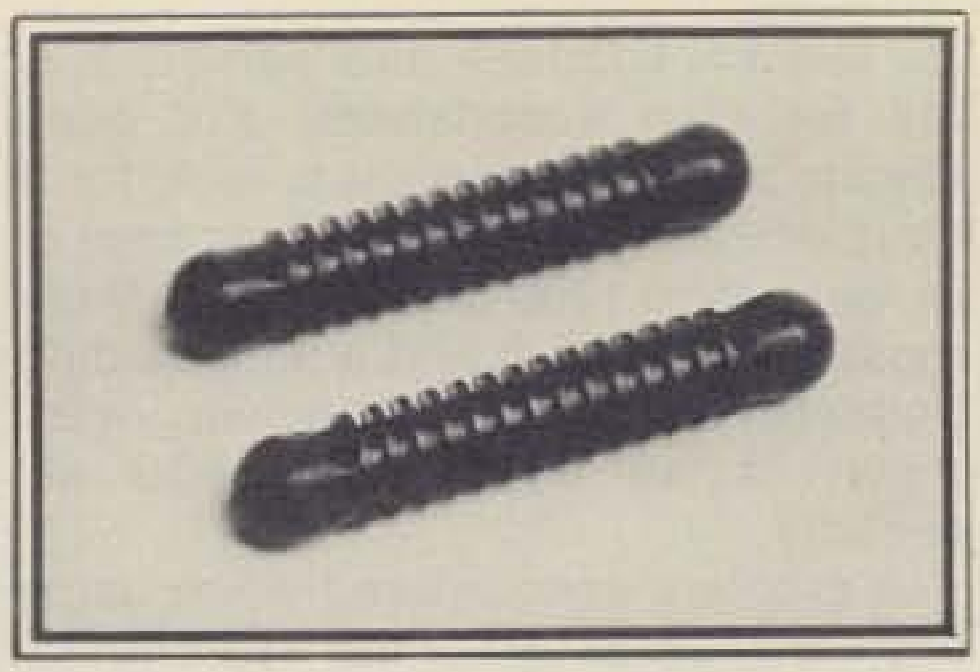
Built from three ceramic feedthrough or standoff insulators and three sections of 1/8" thickness copper or brass bar, the spacing between the axis of the two outside insulators is approximately equal to the transmission line spacing. In practice, the two "gaps" are adjusted just far enough apart so that they don't arc over with full transmitting power applied. Alternately, a heavy shorting bar or even a husky knife switch, installed outdoors, can be used to ground the antenna system when it's not in use. "*When in doubt, ground it*" is a wise old antenna axiom to follow when it comes to lightning!

ground point such as a long rod driven into the earth near the shack.

Light-duty lightning arrestors for use with residential TV and f.m. antennas are satisfactory only for very low-power installations. When medium- and high-power are used, they prove inadequate, since the r.f. voltage on the line is enough to cause them to arc over.

I don't know of any commercially available transmitting-type lightning arrestors for parallel-conductor feedlines; perhaps some readers do. However, a very simple but effective arrestor can be made from three standoff or feedthrough insulators and three sections of brass or copper strapping. Fig. 4 shows such a design.

A 4:1 balun transformer can be used at the antenna feedpoint with many types of dipoles (such as the 300-ohm folded dipole) so that coaxial cable can be used as the feedline. This, of course, eliminates the special problems of lightning protection unique to parallel lines. Since most baluns put the antenna at d.c. ground potential, they offer some degree of built-in protection from lightning. And, you can insert a special coax lightning arrestor (such as Cushcraft's "Blitz Bug" or similar devices by Hy-Gain and Radio Shack) in the line that allows lightning discharges to be routed to ground. *However*, using the balun with an antenna fed in the "tuned feeder mode" probably won't work, since the feedpoint impedance will not be a predictable 300 ohms but will vary considerably from band to band, placing a too-high s.w.r. on the feedline. The balun will also waste a small amount of power, usually around 5 to 10%.



R.f. voltages at the ends of the dipole may be quite high. Rugged insulators such as this 7 in. long pair molded from a high-impact plastic material are heavily serrated to increase leakage paths by a substantial amount. (Photo courtesy Hy-Gain Electronics)

Don't let the problem of lightning protection deter you from using tuned feeders. Build an arrester or ground the lead-in when not using it, and be on your way.

Summary

Several months ago we began a discussion of the dipole antenna family. In the first column we covered the basic dipole, harmonic-dipole operation and multiband paralleled doublets, as well as folded dipoles. In the next column, we branched out to cover the Vee and inverted Vee, the vertical dipole, sloper, T2FD, double bazooka, and both double and extended double Zepps.

In this column, we backtracked just a bit to cover a "special case" dipole very well suited for no-frills multiband operation. We also uncovered the Zepp antenna, also popular for all-band work, though not a dipole in the strictest sense.

Next month, we will highlight another historically popular multiband antenna, the *Windom* and its close cousins. And, in upcoming columns, we'll talk about various kinds of trap antennas. See you then.

73, Karl, W8FX

a monthly feature by
KARL T. THURBER, JR., W8FX

Antennas

DESIGN, CONSTRUCTION, FACT, AND EVEN SOME FICTION

The Window And Its Close Cousins

Last month, columnist W8FX expounded upon the multiband dipole and the end-fed Zepp. In this issue, he updates two old-time versions of the off-center-fed Hertz or Windom antenna of 1930s and 1940s vintage as inexpensive, easily constructed skyhooks. As we shall see, there's room for the Windom and its close cousins in today's antenna picture.

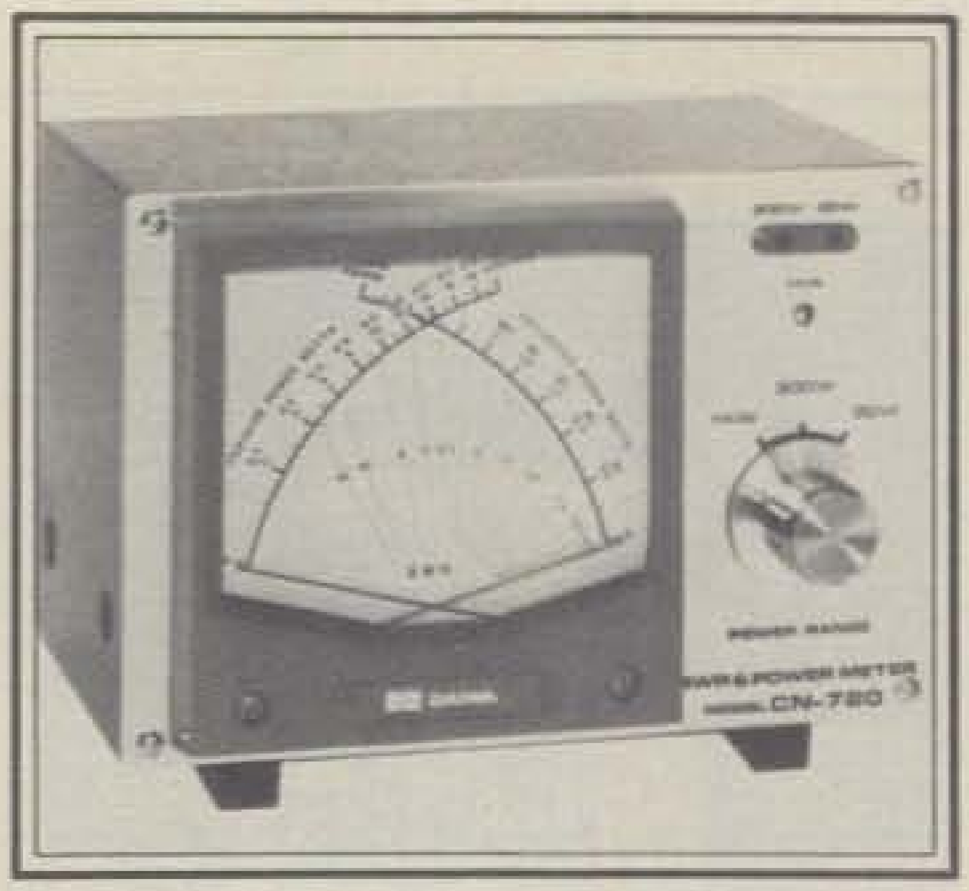
Antenna types vary almost as widely as the amateurs who erect them. For single-band work, the coax-fed dipole is as simple and trouble-free an antenna as one can expect to use. For multiband work, it's hard to beat the dipole fed with tuned feeders, described in last month's column. And the random-length Marconi is an "antenna of chance" especially popular with beginners.

Of course, one can't always have one's cake and eat it too, according to the old saw. The dipole is basically a *single-band* antenna. The all-band tuned-feeder dipole is a great antenna, but its feedpoint impedance varies widely, giving rise to awkward matching conditions. And the random-wire's performance is often just that: random in nature.

The **Windom**, or off-center-fed Hertz, is a popular compromise antenna that boasts many of the desirable characteristics of the centerfed tuned-feeder all-bander, yet exhibits a reasonably constant feedpoint impedance that makes matching and transmitter loading easier than with the tuned-feeder antenna. Let's look at the Windom from the standpoint of a practical and inexpensive solution to the "one antenna for all bands" problem.

The off-center-fed Hertz. This is the original Windom, named after the amateur who developed it and wrote it up for publication in the 1930s. Not seen much any more in the original configuration, the antenna is simply a half-wave (at the lowest frequency band) antenna fed at a point about 15% from the center with a single-wire feeder of any convenient length. (This figure is mathematically derived from studying the current and voltage relationships which exist along the antenna on each band).

*317 Poplar Drive, Millbrook, Alabama 36054



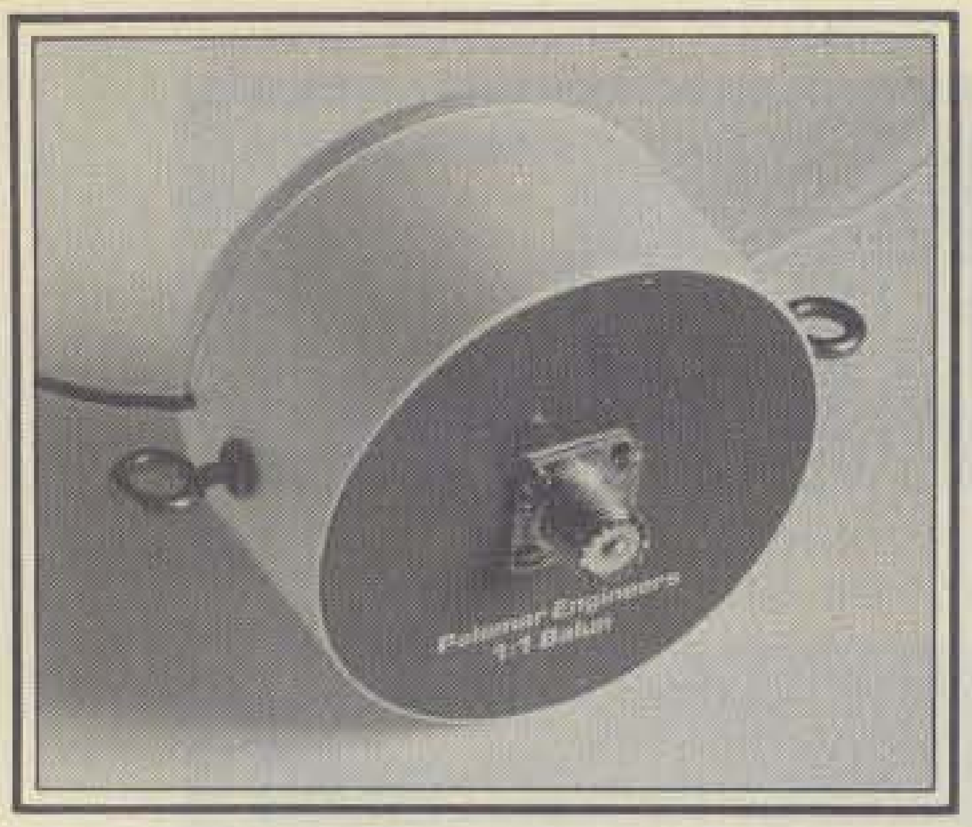
Multiband antennas fed with open-wire line such as the Windom must be fed through an antenna tuner or "transmatch" for proper loading to modern pi-network transmitter output circuits. A real help in rapid tuner adjustment is a dual-scale s.w.r. and power meter such as the Daiwa CN-720 shown here. The meter displays forward power, reflected power and s.w.r. simultaneously. Forward power is read from the scale on the left, the reflected power from the scale on the right, and s.w.r. is indicated on the lines in the area between the two power scales.

This simple, off-center-fed antenna operates only on *even-harmonic* multiples. That is, an antenna cut for 80-75 meter operation will work only on 80, 40, 20, and 10 meters; 15 meters is not covered. Likewise, a flattop with fundamntal resonance on 40 meters will work on 40, 20 and 10—again, 15 meters, having an odd-harmonic relationship with the fundamental frequency, is not covered.

The normal 300-600 ohm feedpoint impedance allows a reasonable match to the nominally 500-ohm single-wire feeder on all even-harmonic-related bands. The impedance will change from band to band; even the optimum spot for the feedpoint appears to vary with height and proximity to other objects. Also, the antenna doesn't exhibit truly "balanced-to-ground" characteristics. For these reasons, resultant performance is hard to predict; some amateurs who have constructed Windoms find that they work fine, while others report that they don't work at all. In other words, when they work, they work great. But when they don't—forget it!

Another problem with the single-wire-fed Hertz (Windom) is similar to that characteristic of all single-wire antennas: the single-wire feed may bring high voltage loops into the shack on some bands, so that you may end up with r.f. on everything in sight. Even with an antenna tuner (a must), you're likely to see this problem rear its head on at least one band, possibly several. Too, the single-wire fed-Windom may aggravate TVI, since the feedline (which radiates to some extent) is brought into the shack, where it has a tendency to pump harmonic r.f. into the power lines, TV leadins, house wiring, etc., triggering r.f.i. and distorting the antenna's radiation pattern. Again, an antenna tuner should be employed, not only to allow proper loading for modern coax-output transmitters, but to increase harmonic suppression and to provide a convenient place to install a lowpass TVI filter (between the transmitter and the antenna tuner or transmatch).

For operation on 80, 40, 20, and 10 meters, a flattop length of about 137 feet can be used, with the feeder tapped at a point 20½ feet (15%) off center. Any convenient single-wire feedline can be used, though feeder lengths of 66 or 132 feet are suggested to minimize loading problems. If 80-meter operation isn't important, an antenna length of 68 feet can be



Palomar Engineers' 2-K balun is designed for inverted Vees, folded dipoles, and other antennas fed with open-wire or twinlead. The particular unit shown is a 1:1 model, but a 4:1 model is also available for use with lines in the 300-450 ohm range. Since the Windom is not a balanced antenna—despite the fact that it is fed with a balanced transmission line—the use of a balun is questionable. The balun may be used, if desired, if the system has at least 90 degrees (¼-wavelength) of balanced transmission line between the antenna feedpoint and the coaxial cable connection (balun). (Photo courtesy Palomar Engineers)

used to work on 40, 20, and 10 meters. In this case, the feeder is tapped at a point about 10 feet off center. Feeder lengths of 33, 66, or 99 feet should give good results.

Although the antenna can't be operated as a Windom on 15 meters, it can usually be fed as a random-wire worked against ground. This requires a wide-range antenna tuner that can handle the likely high input impedance at the transmitter end. Since the antenna will be working against ground, the quality of the ground system becomes critically important, and if lacking, will result in decreased antenna efficiency and increased probability of annoying "r.f. in the shack conditions." If these circumstances arise, adding or subtracting l/8-wavelength of feedline will normally stabilize the situation, although doing so may "throw out" transmitter loading or create "hot r.f." on another band.

As with other single-wire atennas, care should be taken to properly route and insulate the feedline from nearby objects, particularly metal ones in which currents may be induced. The feedline should be brought away from the flattop at right angles for as long a distance as possible before any bends are made.

Figure 1 shows classic off-center-fed Hertz or Windom construction details.

The Windom. The antenna just described, the so-called off-center-fed Hertz, is the classic Windom of 1930s and 1940s fame. But most of us probably think of the twinlead-fed flattop popular in the 50s and 60s as the contemporary version. In this antenna design, shown in fig. 2, the flattop is broken, again at a point abut 15% off-center, and fed by TV-type 300-ohm twinlead. Still not a truly balanced antenna, this kind of Windom—again with a feedpoint impedance running around 300-600 ohms—gives a decent match to twinlead, though by no means a perfect one on any band.

The feedline can be of any convenient length, though at some point a set of impedance-transforming balun coils must be used to convert to 50-75 ohm coaxial cable, or an antenna tuner employed. As indicated, it's doubtful that the 300-ohm feedline is anywhere near matched on any band, so twinlead feedline losses can run high, especially on 10 meters where matching is most critical. The system is vulnerable to parallel line currents due to the unsymmetrical feeder connection. In fact, the feeder may act more like a single-wire transmission line than a parallel-wire feeder on some bands. Nevertheless, this type of feedline is preferred over single-wire feed for a number of reasons. These include fewer problems with induced r.f., reduced potential for TVI, and less reliance on the ground system for satisfactory performance. As with the single-wire-fed antenna, the feedline should run away from the antenna at right angles as far as possible before bending, and no sharp bends should be made anywhere on the line.

Antenna dimensions are the same as with the off-center-fed Hertz version—137 feet for four-band coverage, 68 feet for three-band coverage. Again, 15-meter operation isn't a feature of the antenna. However, it may be possible to successfully operate on 15 meters, albeit with a high s.w.r., by paralleling a 15-meter *dipole* with the Windom. Since the 15-meter antenna presents a very high feedpoint impedance on all other bands, it would appear to be practically nonexistent on these bands and therefore would not much affect performance of the Windom. I haven't tried this, but can't see why it wouldn't work. I'd be interested in learning the results of any reader's experimentation along these paths.

What's the bottom line on the Windom? It's a fact that various versions of the antenna have been widely and effectively used for many years. But it's wishful thinking to expect that the nominal 300-600 ohm feedpoint impedance makes it suitable for direct coax feed at the antenna (through a balun), or that it's superior to the multiband dipole or Zepp fed with tuned feeders because of better matching to the feedline. If I had the choice between the Windom and tuned-feeder type dipole, I'd opt for the latter as a lot more hassle-free and slightly better from a technical standpoint. Nevertheless, the Windom is a good antenna to consider if the location of the shack makes off-center-feed more direct and convenient. I'd also rate the Windom higher than the Zepp for most purposes.

A Word About Transmission Lines. If the off-center-fed Hertz using single-wire feeders is fair, the twinlead version is better, and the open-wire-fed Windom is best.

We've already covered the drawbacks of single-wire feed. Twinlead allows fair matching to the antenna, but it's a lossy line. Twinlead is useful when feeding antennas with *predictable* feedpoint impedances, such as the single-band folded dipole. In this case, s.w.r. is low and line losses are not aggravated by mismatch. However, when s.w.r. is high, the solid-dielectric line becomes considerably lossier, to the point where, on 10 meters, loss becomes very nearly unacceptable. For example, inexpensive TV-type twinlead may have a loss of up to 4 dB per 100 feet at 10 meters even when perfectly matched. If this isn't bad enough, when the line is operated under conditions of 4:1 s.w.r.—possible in the Windom on certain bands at bandedges—another 1.5 dB or more loss will be in-

The most useful and versatile antenna tuners are the wide-range types that can handle a variety of loads and feed systems, and especially those that incorporate a built-in balun transformer so that antennas fed with open-wire feeders may be properly tuned to the desired frequency of operation. Swan ST-2A tuner has 200-and 2000-watt reflected and forward power meters for simultaneous reading. The unit works over the range 1.7-30 MHz, handling antenna system impedances of from 50 to 700 ohms with a 3 kw pep rating. (Photo courtesy Swan Electronics)

troduced into the antenna system. Not only that, but the line is quite sensitive to weather conditions so that its characteristics change markedly when wet or when coated with dirt or dust. These problems can be partially overcome by using specially designed, high-quality cables such as heavy-duty transmitting lines or foam-filled tubular twinlead. Either type will substantially reduce signal loss and also increase the transmitter power level the line can accommodate.

A real improvement in feeding the Windom (as well as the Zepp and center-fed multiband antenna) can be had by using a parallel-conductor feeder known as **open-wire** transmission line. By using this type of line, band-to-band feedpoint variations become less of a concern. Open-wire line has mostly air as the dielectric, with plastic or other insulating spacers placed at convenient intervals to maintain wire spacing. This construction results in a very low-loss line; losses on the order of 0.1 dB per 100 feet at 10 meters when matched are typical. A high s.w.r. is relatively unimportant when using open-wire line, since the additional loss caused by the s.w.r. is negligible. Power handling capability depends on the size and spacing of the conductors used to make the line and the insulators used, but even TV-type open-wire ladder line can handle full legal power.

As mentioned in last month's column, parallel-conductor feedlines require special lightning protection, since both conductors are high above d.c. ground. A simply lightning arrestor was described. The ARRL *Antenna Book* design for an arrestor can be used, too.

For maximum flexibility and precise matching to the transmitter, the Windom should be fed through an antenna coupler, preferably one with a built-in balun coil. However, it is *possible* to feed the antenna directly with coaxial cable through a commercially available 4:1 balun transformer. Doing this assumes a constant 300 ohm antenna impedance, not likely to be the case. A 6:1 ratio balun might be a better choice if a fixed balun is to be used. This would presume a nominal 450-ohm antenna impedance when working into a 75-ohm coaxial cable. If you use a balun to feed a Windom, it's best not to mount it at the antenna but to place it back from the feedpoint at least 90 degrees (¼-wavelength) at the lowest band. Thus, an open-wire feeder of at least 66 feet would be used for an 80-meter antenna between flattop and balun coils.

Regardless of matching results, actual antenna performance will vary from band to band since radiation angle varies with the height of the antenna above ground in terms of wavelength. This is true of any horizontal antenna, including the

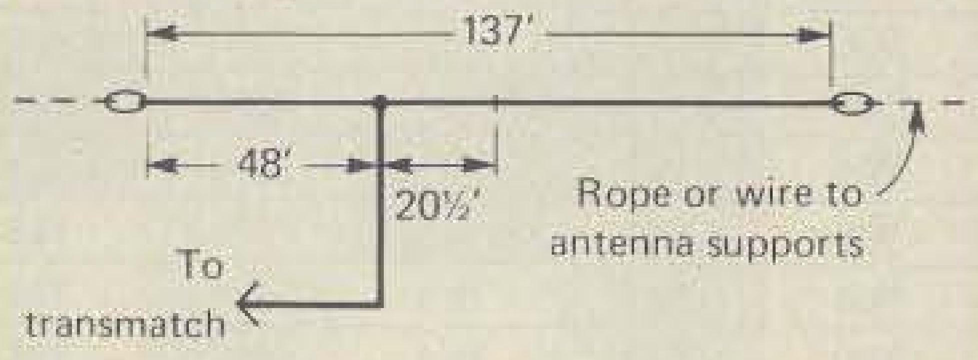


Fig. 1– The off-center-fed Hertz. (Note: The antenna and feedline are constructed of No. 12 or 14 solid wire. Common practice is to use enameled wire for flattop, insulated for leadin.)

The off-center-fed Hertz or "classic" Windom of 1930s and 1940s vintage. The singlewire antenna shown should give a good account of itself on the 80-, 40-, 20- and 10-meter bands with the dimensions listed. Note that the feedpoint is 20½ feet, or 15%, from the center of the flattop. This is equivalent to 48 feet, or 35%, from one end.

If operation on 80 meters isn't required, the horizontal span can be made 68 feet and the feeder connected at a point about 10 feet off center. In either case, any feedline length can be used, but runs of 66 or 132 feet work best with the 80-meter version, and lengths of 33, 66, or 99 feet with the 40-meter antenna.

Since the feedline radiates, bring it away from the antenna at a right angle for as long a distance as possible, carefully routing the line away from metallic objects. Employ a good earth ground system for consistent results.

Although the antenna isn't designed to cover 15 meters, you may be able to get it to load up as a simple randomwire fed against ground.

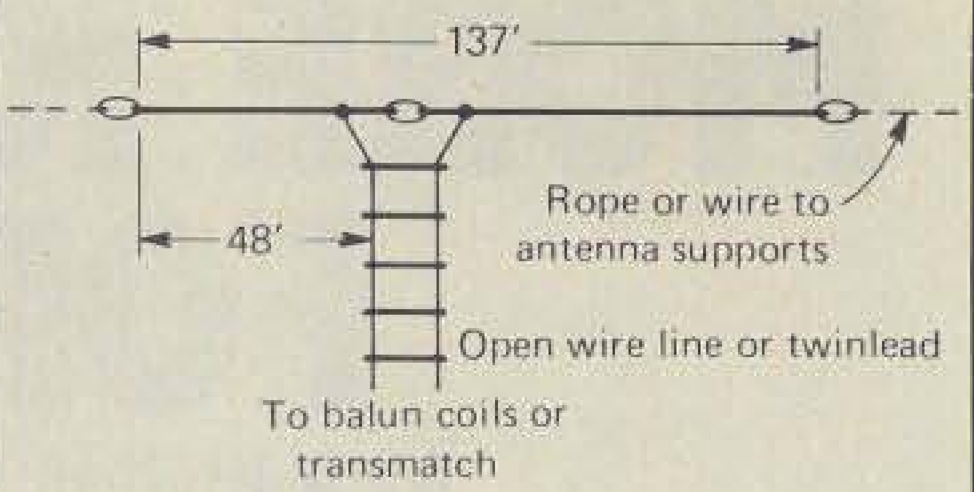


Fig. 2– The basic Windom. (Note: The antenna is constructed of No. 12 or 14 solid wire. Plain enameled is usually used.)

Pictured here is an updated version of the Windom, fed with open-wire line or twinlead. By building to the dimensions indicated, the antenna can be used on 80, 40, 20, and 10 meters with a reasonably stable feedpoint impedance. Note that the feedpoint is selected to be about 15% on one side of the center of the horizontal flattop span, or 48 feet from one end.

If 80-meter operation isn't in your plans, or if there isn't room for the full 137-foot span, a 68-foot antenna can be loaded up on 40, 20, and 10 meters with the feeder connected at the same relative point, as described in the text.

For best results, especially on 10 meters where impedance matching and loading becomes most critical, open-wire feeders should be used. Twinlead, though a popular transmission line, is a poor second choice since most types are lossy and sensitive to weather conditions, dirt and dust. Any convenient feedline length can be used. The antenna should be fed by a balanced antenna tuner or through balun coils.

Although 15 meters isn't normally covered, if you want to work that band, try *paralleling* an ordinary dipole with the Windom. Though it would operate with a fairly high s.w.r. due to the mismatch with the open-wire line, it should enable satisfactory operation on that band without affecting the basic characteristics of the Windom on the other bands.

Please send all reader inquiries directly

Windom and multiband antennas described previously. On 80 meters, for example, with the antenna at relatively low heights, the Windom is a high-angle radiator favoring contacts in the several-hundred-mile range. On 40, 20, and 10 meters, the radiation angle decrease comes out about right for DX on each band.

Fig. 3 shows the relationship of wave angle to antenna height.

Readers' Report

In the first of the new Antenna Columns which appeared in the March 1980 issue, we defined some important antenna terms and concepts. High on the list was the *balun*, which we defined as "a device used in feeding antennas that transforms an 'unbalanced' r.f. system to a balance one, or vice-versa. Typically used to 'match' coaxial transmission line to dipole antennas. May also transform impedance."

In later columns, we suggested that a balun was a handy accessory to use in conjunction with, or to be built into, a transmatch or antenna coupler, for effectively working into open-wire transmission lines. We indicated that this capability would be useful in loading up multiband antennas, such as the center-fed dipole,

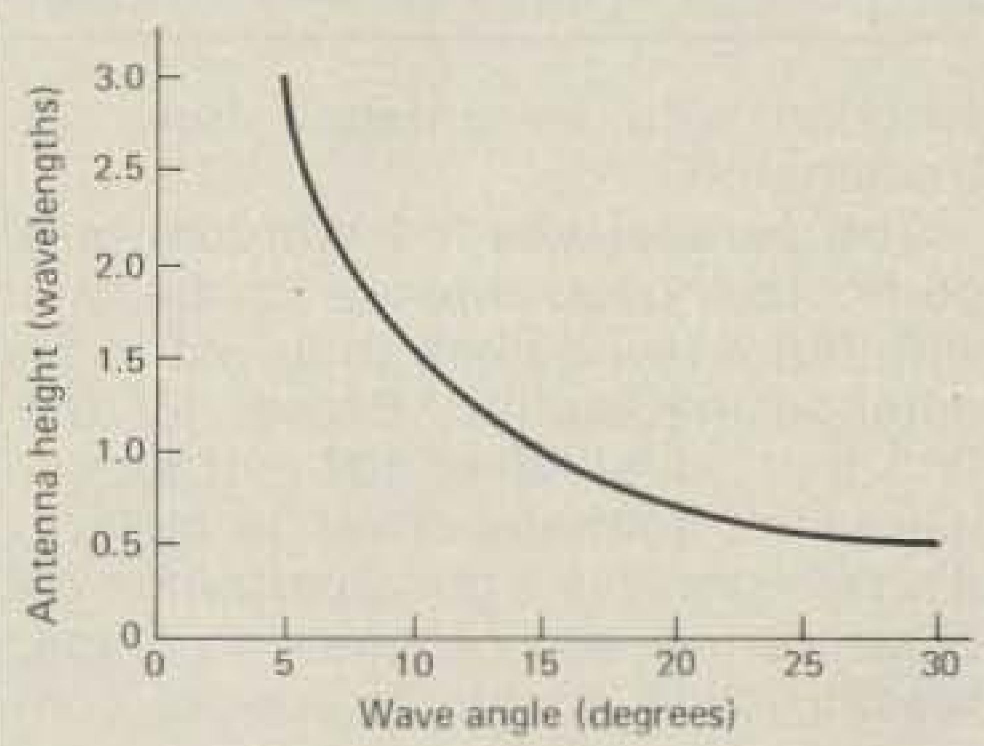


Fig. 3– Antenna height versus wave angle.

Whether we're talking about a Windom, Hertz, dipole, or Zepp, or longwire, the same concepts related to wave (radiation) angle and height-above-ground apply.

As can be seen from a glance at the graph, the greater the antenna height in terms of wavelength, the lower the radiation angle—a "plus" for effective DX work. A point to bear in mind is that while an antenna may take power and "load up" well on any and all bands, its practical performance will vary from band to band as a result of differing height-to-wavelength relationships. Directivity will also vary on different bands.

Zepp or Windom, the subject of this month's column.

A puzzled reader wrote in saying that he understood that it was taboo to use a balun when an antenna coupler was in use, that the two, when used together, would somehow lead to disaster. The basis for his belief was the instruction booklet for a popular heavy-duty balun made by one of the leading U.S. antenna manufacturers. The instructions stated: "**Caution**—Do not use this balun with any matchboxes, antenna tuners, trans-matches, or other such devices. When the balun is used with such a device, out of resonance operation causes the break-down voltage of the balun to be exceeded. This is due to the extremely high standing-wave voltage present on the feedline."

This caution prompted me to read up on baluns and transmatch theory. In my view, the balun and transmatch are distinct devices, each with its own function. The use of both in the same antenna system should not have adverse effects on the other, *if properly used.*

This caveat seems to be the basis on which the manufacturer made his statement. When the balun is used to feed a resonant, unbalanced antenna system such as the simple dipole,

multiband doublet, or beam, the device performs the simple function of transforming transmission line mode from the unbalanced to the balanced condition, i.e., coax to a balanced feeder or antenna. Some baluns also act as r.f. transformers, usually step-ups with a 4:1 ratio for feeding folder dipoles. The key is that the load impedance must be known precisely for the balun to work correctly and not to be subjected to high r.f. voltages which would be present during out-of-resonance operation. These conditions would likely exist if, for example, a 40-meter doublet were fed through a balun on 20 meters; if a 20-meter beam were fed using coax and a balun on 15; or if r.f. were piped through a balun for all-band use of an 80-meter dipole (okay with tuned feeders, but not with coax). This could also happen if a balun-fed Windom were used on 15 meters.

Thus, I can see nothing wrong with using the transmatch and balun in tandem, as long as the balun is husky enough to take the high voltages which may be present. Many transmatches, in fact, *do* incorporate built-in baluns, as we've said, but they are usually built to take some punishment.

Along different lines, another reader sent in a Xeroxed copy of a list of some 16 succinct "Antenna Facts," included in trap antenna promotional literature from Western Radio Electronics. The 'facts' cover a number of plain-and-simple, no-nonsense statements about s.w.r., feedlines losses, feeder radiation, operating bandwidith, loading, radiation efficiency, patterns, pruning and trimming, height above ground, baluns, and traps. Although a few of the antenna facts are oversimplified and they are of course oriented toward the company's trap antenna products, the list represents good sense. At this writing, the 16-item list is included in the literature sent out by the company in response to reader inquiries from their antenna ads. In fact, the company's trap fact sheets and antenna pamphlets represent a comprehensive short course in multiband antennas, and are well worth requesting. The address is Western Radio Electronics, P.O. Box 400, Kearney, NE 68847. We may reprint the list in a future column.

Summary

In last month's column, we covered multiband dipole antennas and Zepps using tuned feeders. In this issue, we covered related antennas— the original off-center-fed Hertz and the modern Windom. These antennas are well suited to multiband operation when properly fed and used in conjunction with an antenna tuner or transmatch.

The parallel-wire-fed Windom is a particularly good antenna for the ham with but a few dollars to invest in an antenna installation. Except for the fact that usual 68- or 137-foot antennas won't normally cover 15 meters, it's nevertheless a good performer on other bands and requires no traps, loading coils, stubs, or special connections. The Windom's been around for nearly 50 years in one form or another. Judging from its popularity, it'll likely be around for another 50.

Next month: we take a look at the much-aligned *longwire* antenna. See you then.

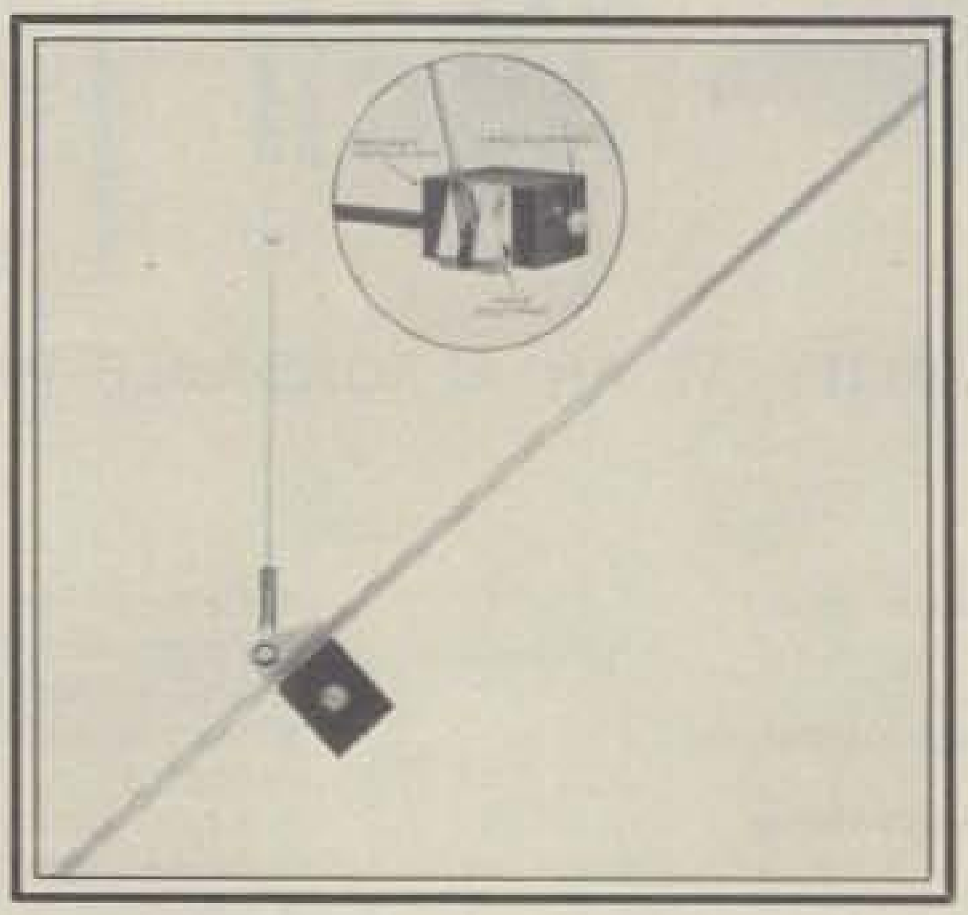
73, Karl, W8FX

Bibliography

Source material and an extended discussion of the antenna topics covered can be found in the references listed below. These, of course, are in addition to the standard reference texts, such as the ARRL's *Antenna Book* and *Radio Amateur's Handbook*, and Bill Orr's *Radio Handbook*, which are available from the CQ Book Shop.

1. Drumeller, Carl C., W5JJ. "Antennas for CBers & Hams," in two parts, *Popular Electronics*, September and October 1973.
2. Marriner, Edmund H., W6BLZ. "How to Construct a Multi-Band Antenna," *CQ Magazine*, March 1954.
3. McCoy, Lewis G., W1ICP. "Choosing a Transmission Line," in two parts, *QST*, December 1959 and February 1960.
4. McCoy, Lewis G., W1ICP. "How to Protect Your Station from Lightning," *QST*, December 1962.
5. Noll, Edward M., W3FQJ. *Ham and CB Antenna Dimension Charts*. Indianapolis: Editors and Engineers, 1976.
6. Schoening, Robert W., W0TKX. "Common Sense Antenna Design," *CQ Magazine*, December 1954.
7. Staff article, "Multiband Antennas—How Not to be Trapped." *73 Magazine*, March 1975.
8. Stanley, J.A. *Ham Antenna Construction Projects*. Indianapolis: Howard W. Sams & Co., Inc., 1969.
9. Stocking, William R., W0VM. "Tuned Feeders and Other Good Stuff," *73 Magazine*, December 1978.
10. Stoner, Donald L., W6TNS. Novice column in *CQ Magazine*, April 1959.

Antenna Of The Month: Avanti Thru-Glass UHF Mobile Antennas (Model AH 450.3G 3/4 meter mobile antenna)



"Look ma—no holes" is the first thought that crossed my mind when seeing the ads for the new thru-glass mounted antennas. The Avanti series for 2-, 1¼-, and ¾-meters does represent an advance for the amateur who abhors making permanent or semipermanent attachments to his vehicle and who doesn't want any external electrical connections to corrode or weather.

Shown here is the smallest antenna of the group, the AH 450.3G, an end-fed, ½-wave radiator for ¾-meter operation. The DC grounded, shunt fed antenna is only 8 inches long and direct-mounts on the glass using a special "fail-safe" epoxy adhesive. The high-Q impedance coupling and tuning unit mounts inside the glass and is capacitively-coupled through the window to the whip outside. Since it's an end-fed design, a ground plane (normally the car body) is not required; thus, the antenna can be used on fiberglass body autos, such as the Corvette.

The patented design is claimed by Avanti to yield a gain equivalent to that of a 5/8-wave deck mounted antenna and to produce a more uniform omnidirectional pattern; a gain of 3 dB over the referenced ¾-wave whip is also stated, as is an s.w.r. at resonance of 1.1:1.

Besides ease of installation, the antenna does offer some real side benefits. All electrical connections are within the vehicle, so service life should be long. There will be little progressive coaxial cable deterioration caused by corrosion or water seepage. And since no ground plane is needed, the antenna system can be used in marine or base station applications.

The contour mount and 180-degree tilt-angle adjustable whip holder are triple chrome plated. Weight is 14 oz. w/cable.

a monthly feature by
KARL T. THURBER, JR., W8FX

Antennas

DESIGN, CONSTRUCTION, FACT, AND EVEN SOME FICTION

Multiband Antennas: The Trap Dipole, Part I

One of the most widely used h.f. antennas is the trap dipole. The trap is extremely popular for several reasons, foremost among them the fact that it can often singlehandedly replace a small antenna farm. In this article, our columnist W8FX gives traps the plain-vanilla treatment.

In 1955, Chester Buchanan, W3DZZ, popularized in *QST* a little-known but technically excellent technique for adapting the dipole for multiband use. The concept was originally developed, back in 1940, it is said, by an intrepid radio engineer named Howard K. Morgan, who published his concept in *Electronics* magazine. This involved the introduction of lumped constants, or tuned circuits, at strategic points in a wire antenna to allow it to *simultaneously* develop resonance on two or more amateur bands.

These tuned circuits soon took on the nickname of "traps." Antennas designed along these lines included trap doublets, beams, and even verticals. By the late 50s and early 60s, just about everybody was into traps, since their development culminated a long search for a single, coaxial-fed antenna that could be used on several bands with the newfangled band-switching transmitters of the day.

The trap antenna is increasingly popular today, especially in view of shrinking urban real estate lot size, trends to apartment and condominium living, and restrictive covenants on land use that suggest or even dictate that a minimum number of antennas serve one's hamshack.

In this month's column, we will continue where we left off in our discussion of the doublet to focus on the **trap dipole.** We will highlight the "why" behind the trap antenna, describe how it works, discuss feeding and matching procedures and techniques, and point out some important installation considerations. We'll leave trap verticals and beams for another time.

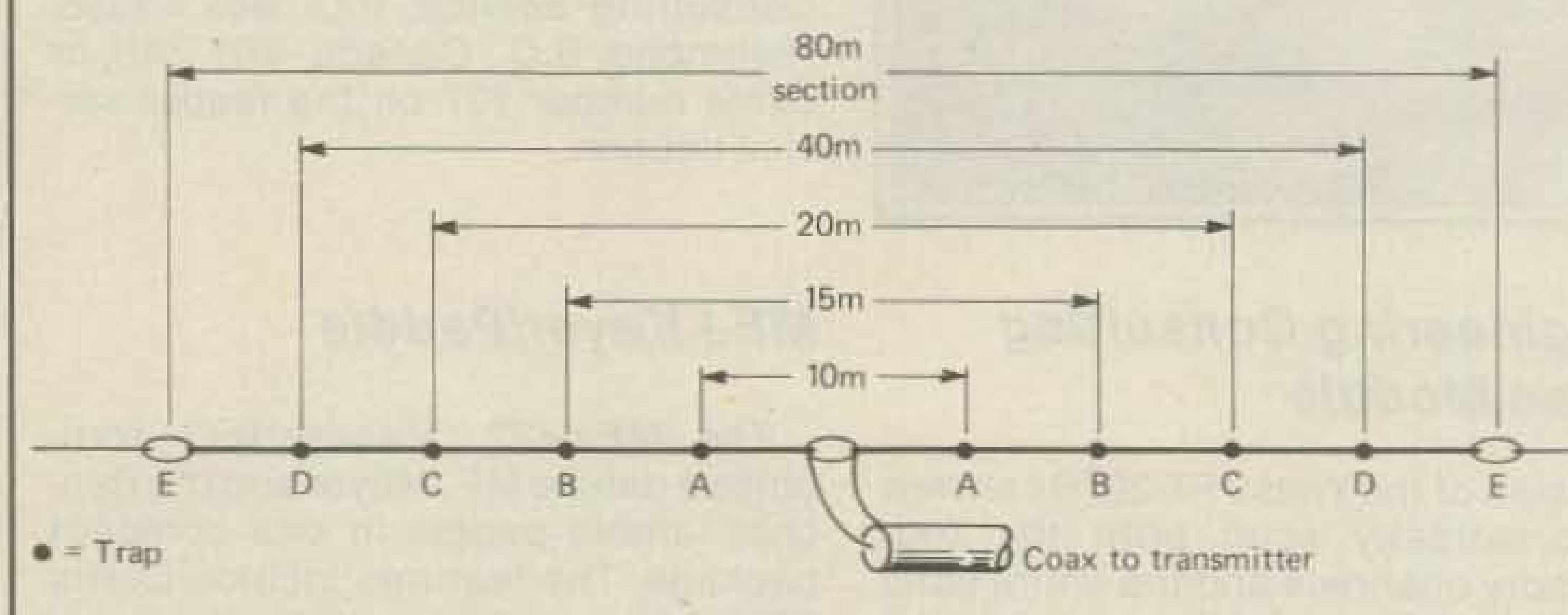


Fig. 1– The horizontal trap dipole.

How traps work in a typical, 5-band multiple-trap antenna. The antenna uses *four pairs* of traps, for a total of eight, for simultaneous resonance on the five bands.

The innermost section, A:A, makes up the 10-meter antenna. The traps at the end of this dipole section make up a resonant L/C circuit that isolates the outer portions of the antenna when working on 10. The outer sections B:B, C:C, and D:D function in similar fashion for the lower bands. On the lowest band, 80 meters in this case, the full antenna (E:E) resonates as a half-wave dipole, but it is somewhat shorter than formula length due to the loading effects of the traps.

A five-band dipole can be constructed with as few as one pair of traps, but operation on the higher bands (20, 15, and 10) is somewhat chancy, since the traps cause the antenna to operate in a harmonic mode on those bands, with actual resonance and resultant s.w.r. not easily predictable.

The trap antenna is usually fed with coaxial cable, but transmitting-type 72-ohm twinlead may also be used. A balun is not required for coax feed, but may be installed if desired.

Why The Trap Antenna?

Most amateurs who want to conveniently operate on the popular h.f. bands are faced with the problem of finding space or overcoming zoning or landlord restrictions to erect a number of separate antennas to cover each of the six bands—not to mention the additional three segments potentially gained as a result of WARC-79. For the amateur who is space limited—and that's most of us—there are several options. He can erect a singlewire or randomwire type antenna using the longest flattop that his property can accommodate. He can use a long dipole, cut for resonance on the lowest band to be used, feeding it with open-

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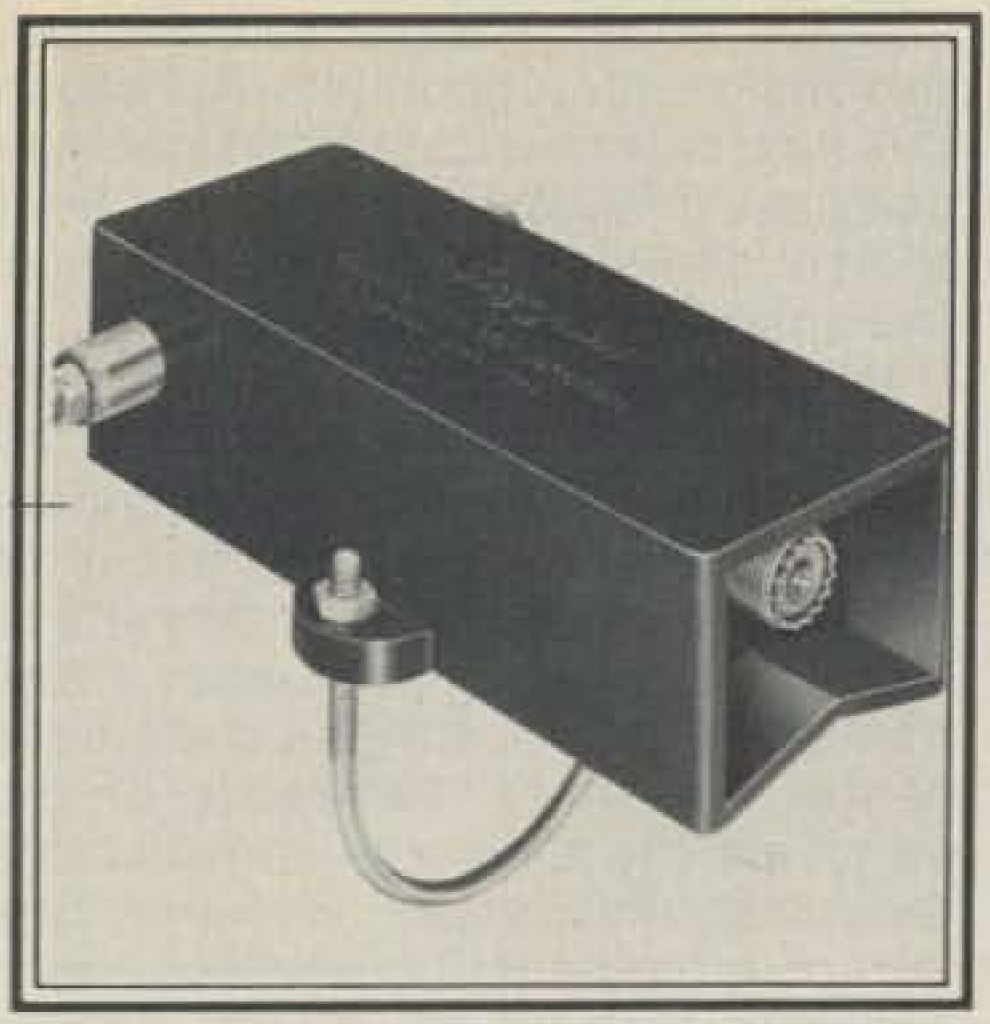
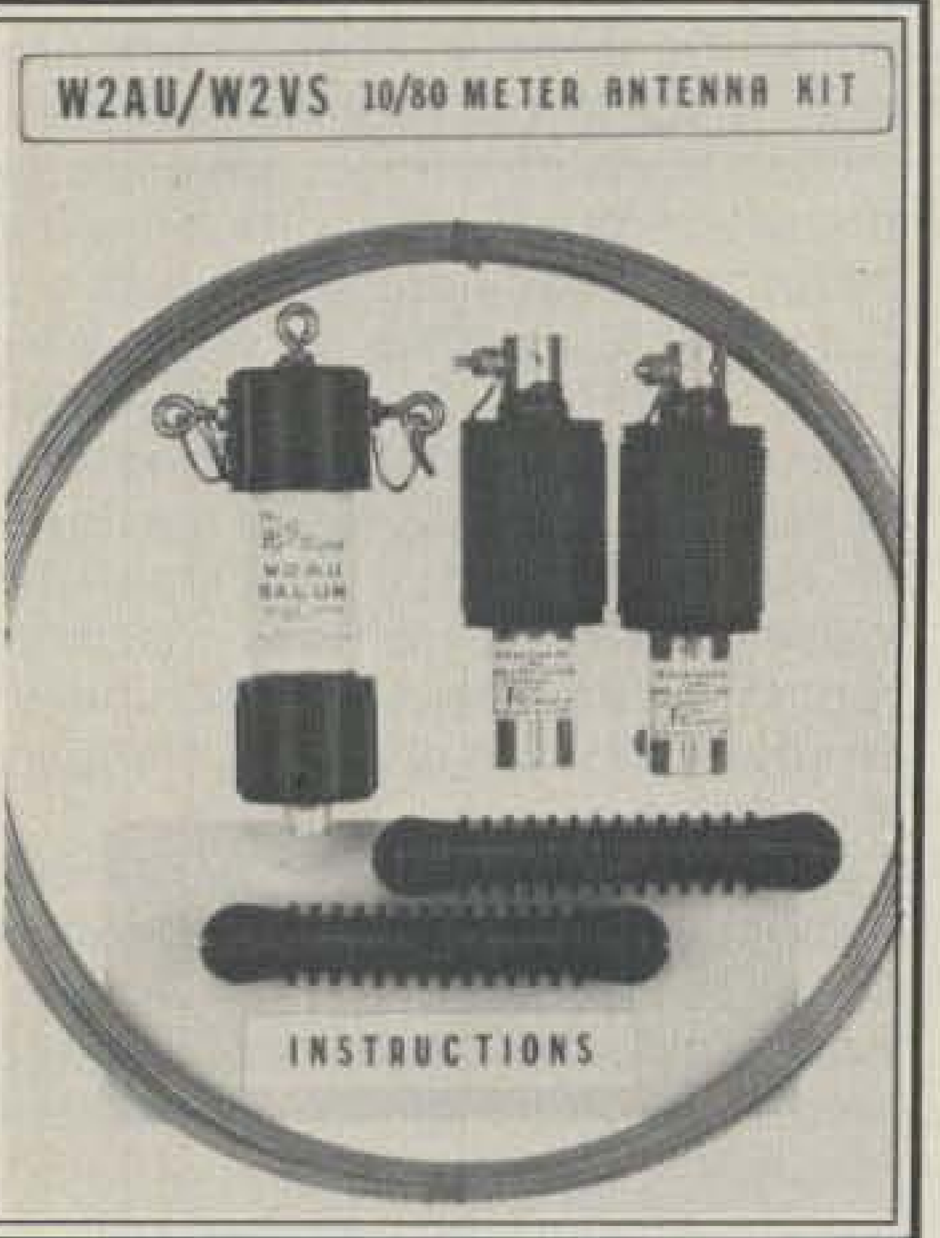


A balun is usually recommended with trap and other type dipoles when fed with coaxial cable to correct unbalanced conditions. Shown here is a Hy-Gain ferrite balun that permits coupling of a 52-ohm unbalanced transmission line into a 50-ohm balanced system for beam or doublet antennas. The unit is frequency independent and will therefore operate properly over all the h.f. amateur bands. (Photo courtesy Hy-Gain Electronics)



Complete 5-band trap antenna kit based on the W2AU/W2VS trap design. Primary half-wavelength resonance is achieved on 80 and 40 meters, and the antenna operates on multiple half-wavelengths on the three highest bands—10, 15, and 20 meters. Result is an effective antenna with very low s.w.r. on 40 and 80 and somewhat higher s.w.r. on the higher bands. The traps used are the basic KW-40 (40 meter) traps; if a lower s.w.r. is desired on one or more of the higher bands, the appropriate pair(s) of traps can be added. Accompanying sketch shows the kit installed. (Photo courtesy Unadilla/Reyco)

wire line as a tuned doublet. Or he can hook several dipoles in parallel and feed them through a single coaxial transmission line.

All of these are practical solutions to the problem of operating on multiple bands with one antenna. However, there are very real drawbacks. The singlewire antenna's feedline radiates, it's very much dependent on the ground system for good performance, and an antenna tuner is required. The tuned doublet requires inconveniently handled open-wire line, as well as an atenna tuner. And the multiple dipole is physically cumbersome and sometimes plagued with interaction between the several paralleled dipoles.

The trap antenna eliminates most of these problems and represents an excellent choice for the amateur who wants relatively hassle-free multiband operating capability. A single trap antenna can take the place of six or more dipoles individually cut to resonance. The trap system will have essentially similar radiation pattern, efficiency, and characteristics as if it were erected as separate antennas. Although there is some loss in the traps, this is usually insignificant when weighed against the *overall* losses of other systems, such as loss from feedline radiation, inefficient grounding, poor matching, etc.

Let's turn now to a discussion of *how* the traps work.

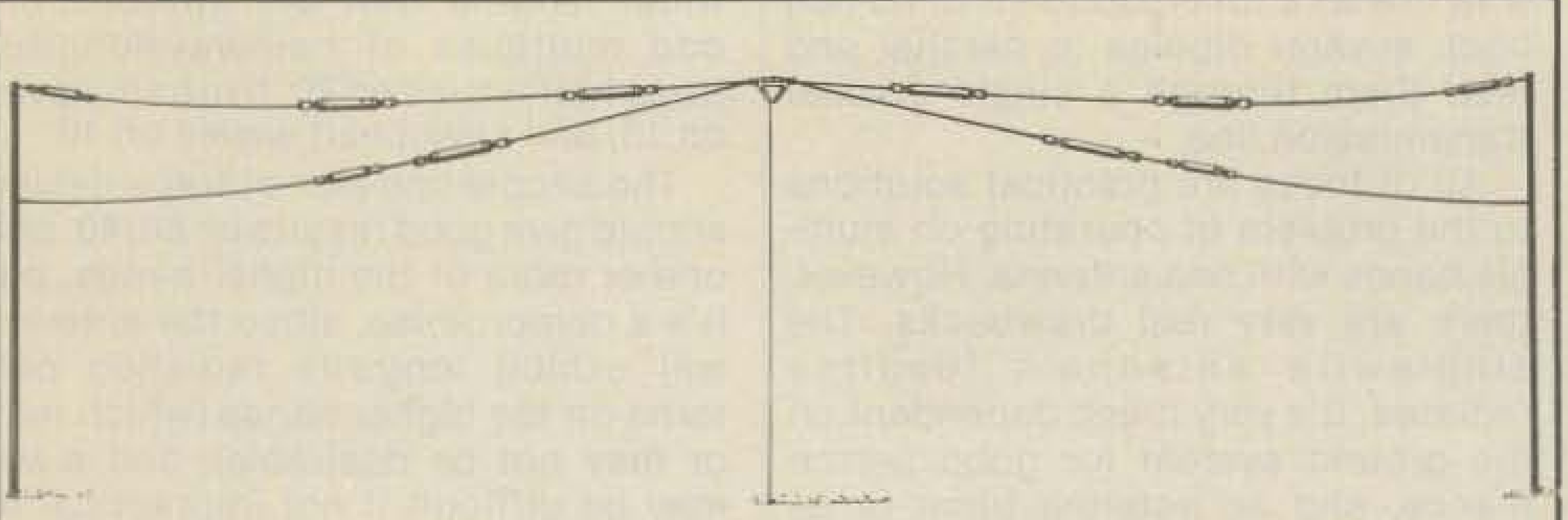
The Trap: How It Works

The trap dipole uses lumped constants (capacitors and inductors, forming tuned circuits) the function of which is to electrically connect or disconnect the outer sections of the dipole as bands are changed. The parallel-tuned L/C circuit presents a very high impedance to r.f. current flow at the resonant frequency; thus it acts as a "trap" for r.f. so as to electrically chop off the flattop beyond that point. At frequencies above and below trap resonance, the trap acts as a short-circuit so r.f. readily passes through it.

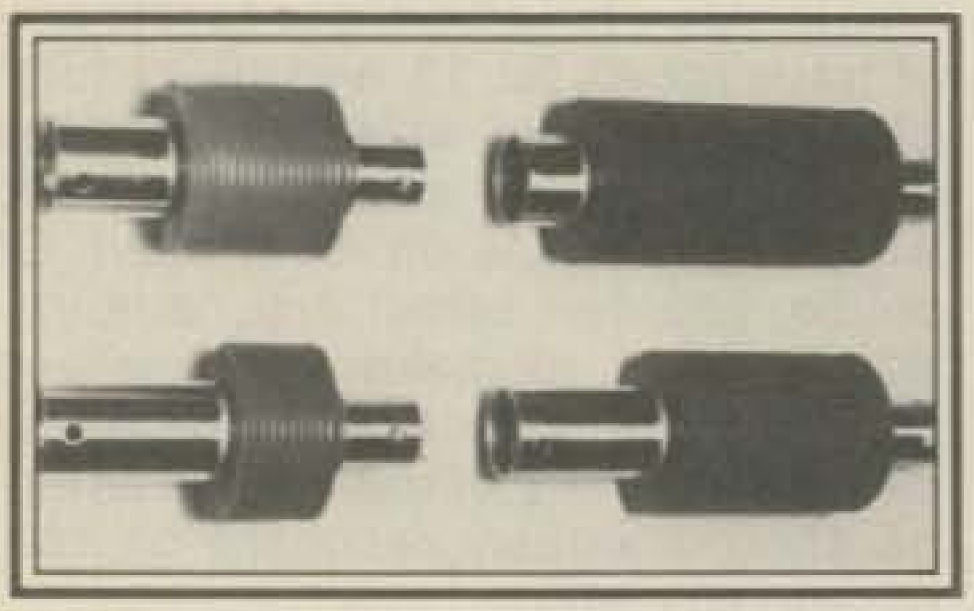
Several different trap arrangements are possible. In one of the simplest, a single pair of traps is used to secure operation on all bands from 80 through 10 meters. Using a flattop length of 100-110 feet for 80 meters (the shortening being due to the loading effect of the trap), the antenna operates as a full-size dipole. On 40, the traps divorce the outer wire sections so that the antenna behaves, electrically speaking, as a 40-meter dipole. However, on the three highest bands (20, 15, and 10), the antenna functions like a centerfed longwire, with electrical lengths that are *approximate* odd multiples of half-wavelengths: three half-waves on 20, five half-waves on 15, and seven half-waves on 10.

The simple one-pair-of-traps design should give good results on 80, 40, and one or more of the higher bands, but it's a compromise, since the antenna will exhibit longwire radiation patterns on the higher bands (which may or may not be desirable), and s.w.r. may be difficult if not impractical to control on those bands. Trap adjustment to bring a particular band to resonance may throw off another band. To remedy this situation, *multiple* traps can be installed, one being required for each band except the lowest. To cover the five bands, for example, you would need a separate *pair* of traps for 40, 20, 15, and 10—a total of eight. In this arrangement, the antenna works as a true half-wavelength dipole on each band. Of couse, you can select any combination of traps to make a specialized multiband antenna. For instance, you can use two pairs of traps for an antenna simultaneously resonant on 160, 80, and 40 meters.

Trap antenna efficiency is good. While the efficiency of the trap dipole is somewhat lower than separate



Representative Hy-Gain trap doublet is shown here. Unit is a 94-foot dipole designed for operation as a true half-wavelength on each band (10, 15, 20, 40, and 80 meters). Large diameter coils contribute to a favorable L/C ratio and high-Q performance. The antenna can be installed horizontally or in an inverted Vee configuration. (Drawing courtest Hy-Gain Electronics)



Representative transmitting dipole traps. At resonance, the trap is an open circuit and cuts the dipole to resonant frequency. In the W2AU/W2VS trap system, distributed by Unadilla/Reyco, two traps (1 pair) are required for 80-10 meter compromise operation. Use of five full pairs of traps will allow primary half-wave resonance on all bands, 160 through 10 meters.

dipoles for each of the bands (due to the fact that the traps are not perfect insulators), the loss is not significant in a carefully adjusted multiband trap antenna using good dielectric quality, high-Q traps, though operating bandwidth may be restricted as opposed to full-size, unloaded dipoles. The traps can be homebrewed, although commercial versions are inexpensive and probably feature better mechanical construction than most of us can duplicate.

While we're mainly concerned with the basic trap dipole this month, we should point out that traps can be used in a variety of multiband antennas in much the same way they are used in the doublet. Traps can be combined with loading coils to produce physically short multiband antennas, used to make up high-gain collinears for the higher bands, incorporated in vertical antennas, and employed in multiband parasitic beams. With only slight reduction in operating efficiency, the traps can allow a single antenna, whether it be a dipole, vertical, or beam, to take the place of five or six separate antennas—more when the new WARC-generated bands phase in.

Fig. 1 shows typical trap dipole configuration and technical details.

Feeding The Trap Antenna

The beauty of the trap dipole is that bandswitching inherent in the trap design is a natural for the no-tune solid state amplifiers found in newer transmitters and transceivers.

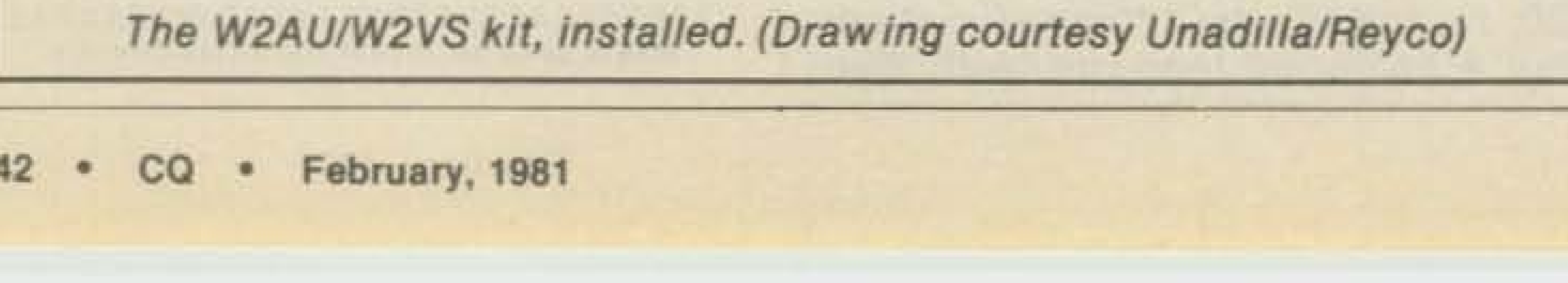
Normally, the trap dipole is fed with 50- to 75-ohm coaxial cable. Losses are low enough to use the smaller cables (RG-58/U or RG 59/U) on runs up to about 100 feet at moderate power levels. For longer runs and when high power is used, lower-loss (preferably polyfoam) RG-8/U or RG-11/U should be installed. The new thin-body, lightweight RG-8X cable is just right for trap dipole feed, especially since its weight doesn't make an already heavy antenna sag even more. Low-impedance twinline (72 ohm) can be used, also. Since it's a balanced line and the antenna itself is balanced, this makes for a good match, though this kind of leadin is often lossier than coax and it radiates more. If you want to use twinline, stick to the low-loss, transmitting-rated kind.

What about the use of a balun? Since the trap dipole, like others of the family, is a balanced or symmetrical antenna, if you use coaxial cable for the transmission line you may want to install a 1:1 balun transformer at the center of the flattop in lieu of a simple center insulator. The merits of the balun are the subject of considerable technical discussion. However, the use of a high-quality, low-loss balun can help equalize r.f. current flow in the system and prevent antenna currents from flowing down the *outside* of the coaxial cable, with possible distortion of the antenna's radiation pattern and possible TVI and BCI as results. Use your own judgment; use of the balun is *not* an absolute requirement.

With a reasonably well-adjusted antenna and a short feedline using low-loss coax, it's not necessary to worry unduly about achieving a perfect s.w.r. on all bands. With single-pair trap antennas, it's virtually impossible to achieve a 1:1 s.w.r. on all bands; even with multiple-trap versions, it's difficult. If you have problems loading up your solid-state rig (whose transistor finals are quite sensitive to high s.w.r. conditions and are therefore usually protected with a circuit which cuts them off when a high s.w.r. is sensed), you'll want to use a coax-to-coax antenna coupler or transmatch in tandem with the rig. Use of the transmatch will facilitate loading, although it does mean that two or three additional knobs have to be adjusted when changing frequency or switching bands.

Most modern amateur transmitting equipment has adequate harmonic radiation protection. However, while most single-band antennas will reject *even* harmonics of the fundamental frequency, the trap may efficiently radiate *all* harmonics; that's its job. For this reason, the use of a transmatch in the line is especially recommended even if high s.w.r. and loading aren't a problem with your antenna. This is particularly important for Novice trap antenna operation on 80 and 40 meters using older tube-type equipment. Too-heavy loading of the pi-network output circuits in these rigs can destroy harmonic suppression and cause second-, third-, and higher-order harmonics to be smartly radiated with unncessary interference and an FCC citation as possible results.

(To Be Continued)



The W2AU/W2VS kit, installed. (Drawing courtesy Unadilla/Reyco)

a monthly feature by
KARL T. THURBER, JR., W8FX

Antennas

DESIGN, CONSTRUCTION, FACT, AND EVEN SOME FICTION

Multiband Antennas: The Trap Dipole, Part II

This month we conclude our discussion of trap dipoles with installation and radiation consideration. W8FX also delves into reader mail and really picks an interesting winner for Antenna Of The Month; unfortunately it's not one you can pick up easily from your local distributor. —K2EEK

Installation Considerations

High, free and clear trap antenna installation is even more important than with simple, singleband dipoles. This is because trap resonances can be upset if not installed in the clear, and metal objects in close proximity to the flattop can affect trap operation as well.

A few rules-of-thumb should be useful. The trap dipole should be installed at least a full wavelength from buildings or other large obstructions, especially power or telephone lines, if possible. It should be mounted as high as possible; 30 feet is a good minimum to shoot for. Rope or heavy-duty plastic clotheslines or wire (with resonances broken up with strain insulators) can be used to support the ends. The transmission line should be brought away from the antenna at right angles for as long a stretch as possible. It's especially important not to bend the ends of the antenna either vertically or horizontally to squeeze it into a limited space. Doing so may detune the traps and upset their operation, as well as distort the radiation pattern in an unpredictable fashion.

If you can't fit the antenna in without a bend of some kind, consider the inverted-Vee arrangement. This requires only one high center support, the ends being sloped down and tied to lower supports. A number of commercial baluns and center insulator assemblies sport a convenient hang-up hook that is just right for the Vee. Many DXers prefer this configuration even if space isn't at a premium, since there is some gain on the higher bands and the antenna's angle of radiation (good for DX) is lowered.

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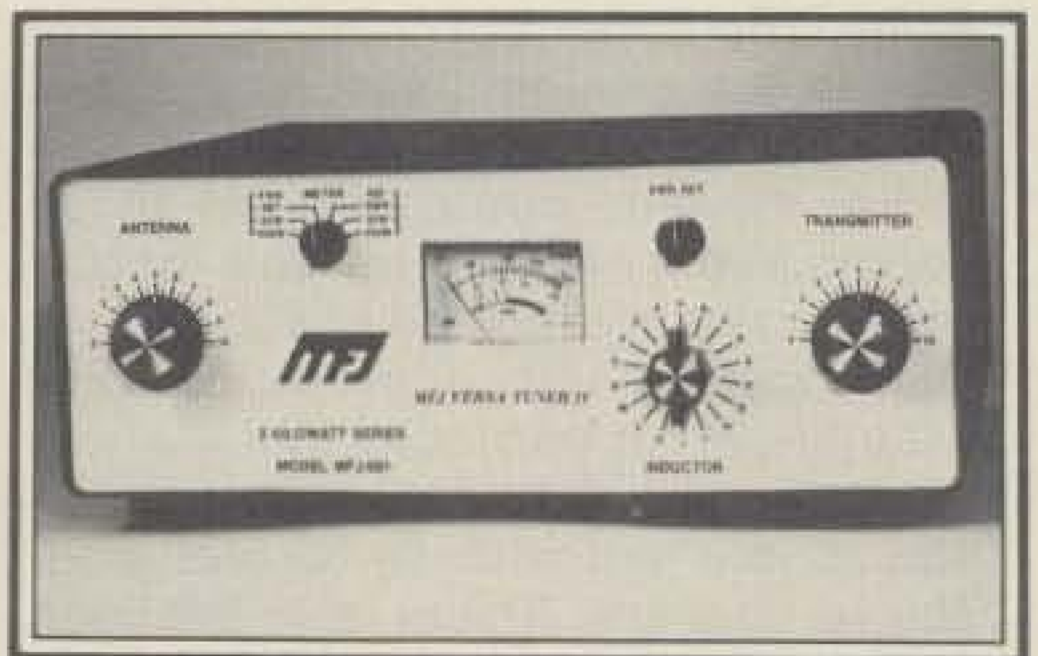


Trap antennas are great for enabling operation on several bands with a single antenna, although there's no assurance that low s.w.r. and proper transmitter loading can be maintained on all bands. Use of a coax-to-coax antenna coupler helps ease the line match to the transmitter. In addition, trap antennas—like most all multiband radiators—are notorious harmonic generators. The tuner will add a great deal of selectivity to the antenna system, which will normally reduce harmonics to an acceptable level. Representative wide-range MFJ high-power capability tuner is shown here. (Photo courtesy MFJ Enterprises)

What About Radiation Pattern?

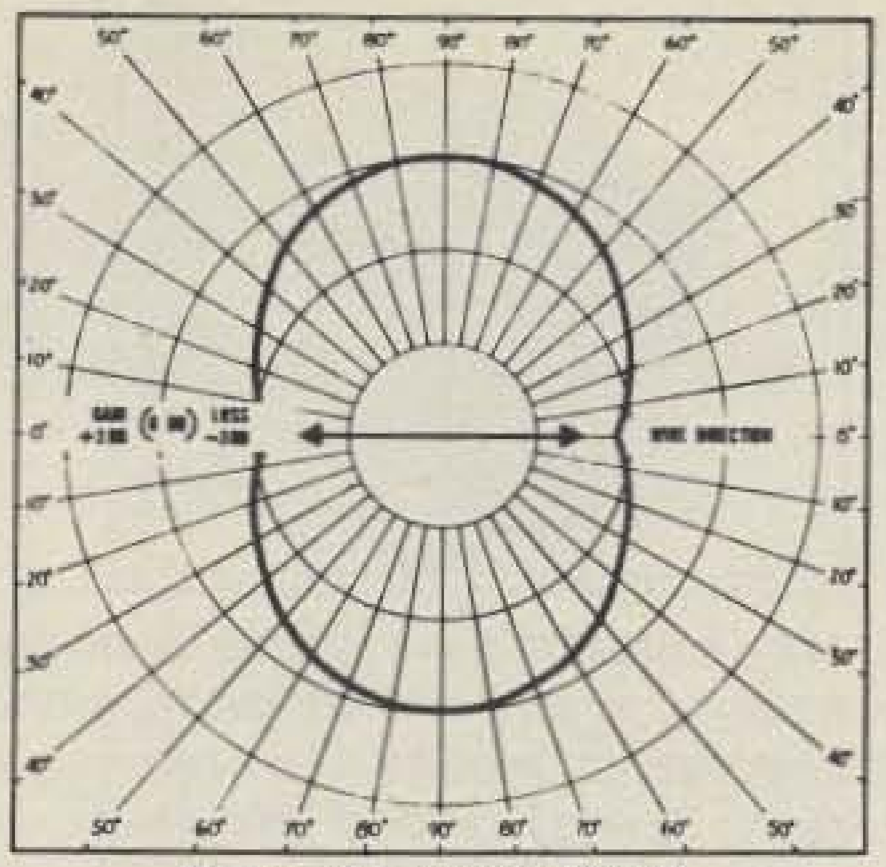
Like other horizontal antennas, *vertical* radiation angle depends on antenna height above ground; the higher the antenna, the lower the angle of radiation. For most practical antenna heights, maximum radiation will be about 30-35 degrees from the horizontal. This assumes an antenna height of one-half wavelength. If less, as on the lower h.f. bands, radiation angle will be higher. If more, as on the higher bands, it will be lower.

The trap's horizontal radiation pattern is essentially that of the basic dipole: bi-directional, doughnut or figure-8 shaped, with maximum radiation occurring at right angles (90 degrees) to the axis of the wire.

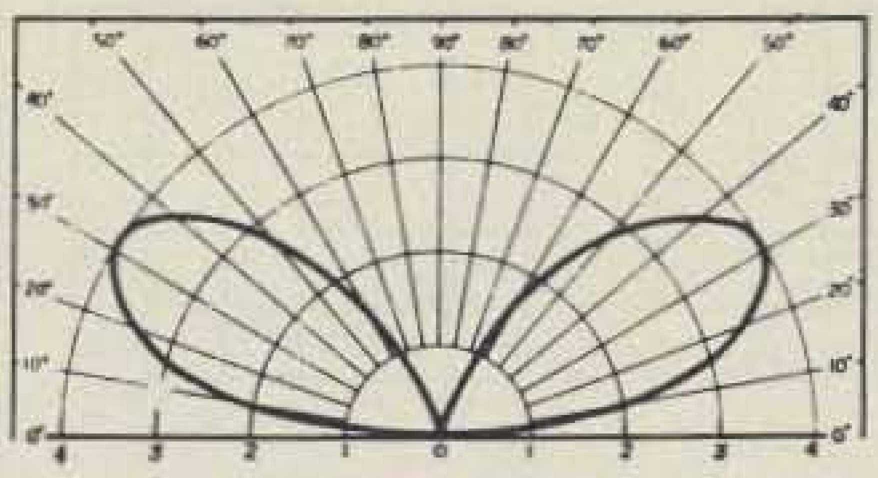
The classic figure-8 pattern assumes that the antenna is operated in a true half-wavelength mode on each band, that is, that multiple traps are installed. However, the simple bi-directional pattern tends to the cloverleaf on the higher bands where the single-trap antenna takes on the characteristics of the longwire. As the antenna becomes longer and operates on harmonic modes (3/2-, 5/2-, 7/2-wavelengths, etc.), the number of lobes formed as well as directivity increases. However, at practical heights above ground, the nulls in the pattern aren't too sharp, and the pattern tends to fill in so that directivity becomes pronounced primarily on the higher bands. If installed as an inverted-Vee, the antenna becomes more sharply directional. Fig. 1 shows basic antenna patterns.

Trap Adjustment

Trap adjustment is a subject unto itself. Since most commercial traps are factory tuned and sealed, it's the wire section lengths that are adjusted to whip the antenna resonance points and resultant s.w.r. into shape. An s.w.r. bridge can be used for adjustment, although more precise results can be obtained using a grid-dip oscillator or antenna noise bridge. Typically (but following the trap manufacturer's adjustment instructions, of course), one starts with the highest frequency band covered by the antenna, noting s.w.r., resonance or impedance characteristics, depending on the measuring instrument being used. The center wire sections are then adjusted—either lengthened or shortened—until the antenna is resonant to the desired frequency. The procedure is repeated on the next lower frequency band, working down until you have adjusted the lowest-frequency sections. Using the one-pair-of-traps configuration, you go through this procedure for the two lowest bands only; the s.w.r. on the

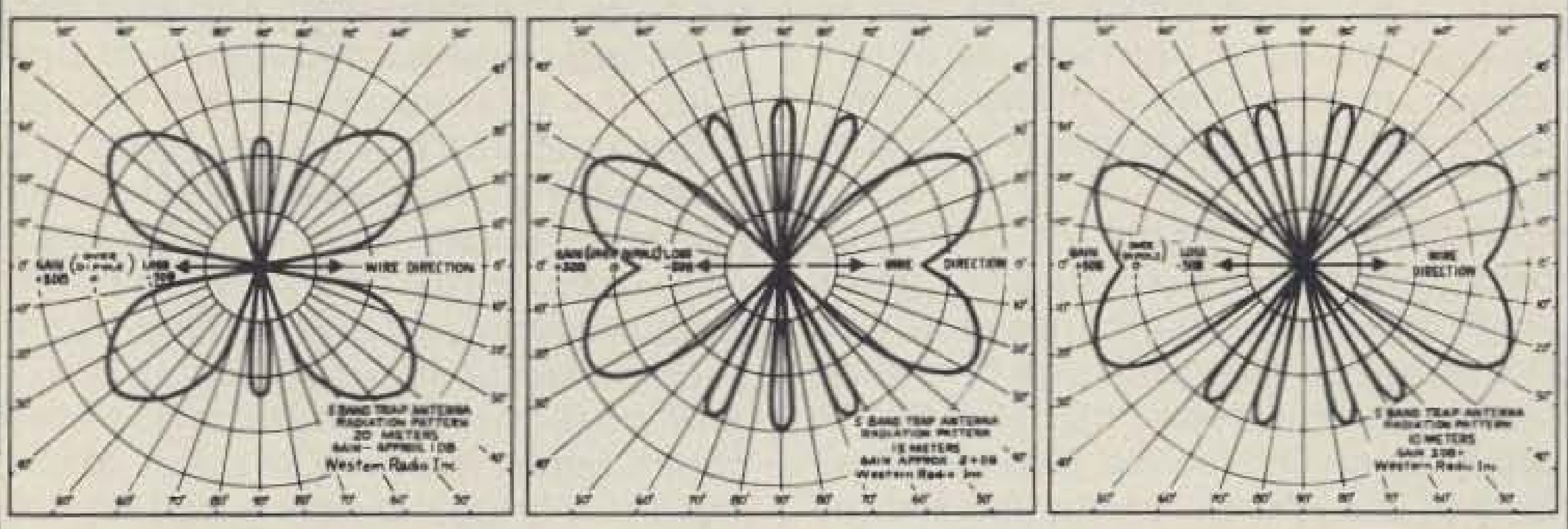


Horizontal Radiation Pattern
of Horizontal Dipole ½ Wave Length High



Vertical Radiation Pattern of
Horizontal Dipole ½ Wave Length High

Shown above, at left, is the typical horizontal radiation pattern for a half-wavelength dipole at a height of one-half wavelength above ground. This pattern holds as long as the trap dipole has a pair of traps for each band. At right, expected vertical pattern of a dipole one-half wavelength high.



Above, typical trap dipole patterns for single-trap-pair antennas on the higher bands. As can be seen, the familiar doughnut-shaped pattern shifts to the cloverleaf as the antennas are operated in harmonic modes, directivity sharpens, and some gain develops. (Source: Western Radio product literature.)

Fig. 1–Trap dipole radiation patterns.

higher bands (20, 15 and 10) is not adjustable, though you may experiment with various antenna feedline lengths if transmitter loading is a problem to coax the rig into pumping power into the system. With antennas that have separate traps for each band, you go through the whole procedure for all bands. Adjustment may take quite some time, and there may be considerable interaction in making the adjustments. But, with perseverance, the result should be a very low s.w.r. antenna on all bands.

Fig. 2 shows typical multiband trap antenna s.w.r. curves.

Reader Reports

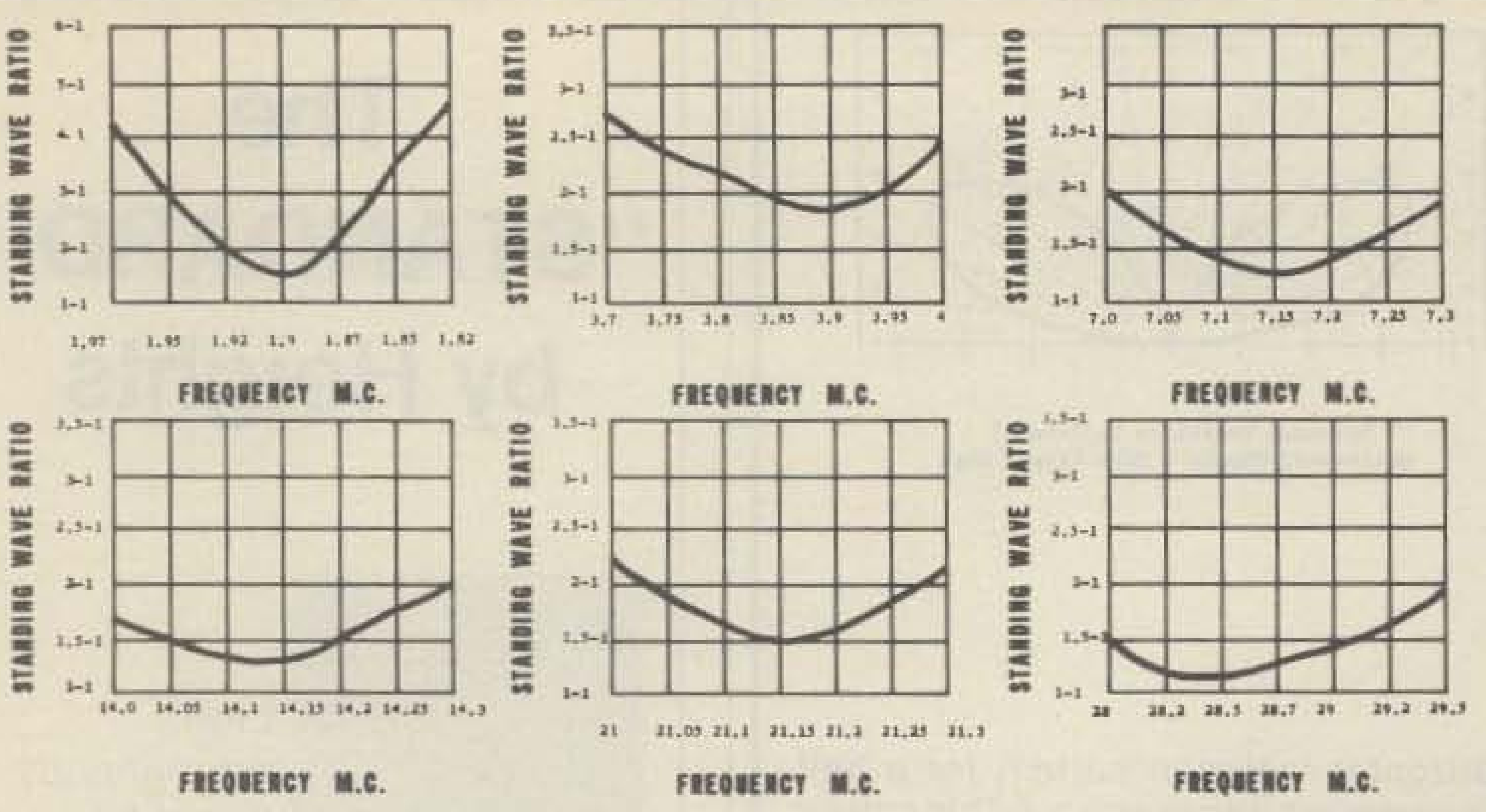
A Connecticut reader who has been corresponding with me about his antenna problems wrote requesting my views on a two-band indoor (attic) trap-loaded antenna he was considering for 80- and 40-meter use, one that would have to be bent to fit his attic's 37-foot width. (Very little room was available outdoors to run a dipole of even modest dimensions.)

Though I am a believer in loaded dipoles, I had to reply that antennas always seem to work better outdoors, in the clear, even if bent and electrically loaded to resonance. The indoor antenna will undoubtedly pass near electrical wiring, heating ducts and water piping, which will have an adverse and unpredictable effect on performance. Also, one runs the risk of r.f. getting into everything from the telephones to TVs to stereos.

In fact, I once ran high power into a full-size 40-meter dipole strung in the attic of a quadplex apartment and was surprised the very first night to receive a knock on the door from an irate and confused neighbor. Seems he had retired for the evening, turning out his lights, but woke up to pulsations of his bedroom ceiling light glowing in step with my s.s.b. modulation! Apparently, sufficient r.f. was rectified by his wiring to light the lamp even though his a.c. wall switch was turned off. (I never ran high power into that antenna again, and shortly thereafter took it down.)

Some suggestions I conveyed to my W1 correspondent as alternatives to his indoor designs included the following:

1. A loaded inverted-Vee off the top of his beam tower.



Charts above show one manufacturer's typical trap curves for the six present h.f. bands, 160 meters included.

Any multiband antenna system represents a compromise of some sort to allow convenient use of the antenna on more than one band. With the trap antenna, the tradeoffs result in slightly higher minimum s.w.r. and somewhat lower operating bandwidth, especially on the lower bands relative to the dipole at comparable heights above ground.

The Western Radio s.w.r. curves show worst-case s.w.r., for their multiple-trap antenna, of less than 2.5:1 on all bands except the two lowest, where s.w.r. at the band edges of 160 and 80 meters runs as high as 4:1. This is not necessarily a problem, since the traps can be adjusted to center on one's favorite operating range and the antenna can be fed with low-loss versions of RG-11/U or RG-8/U, or the new, lightweight RG-8X to minimize transmission line losses. And an antenna tuner can be used at the transmitter end of the line to "clean up" the impedance presented to the rig. (Source: Western Radio product literature.)

Fig. 2- Trap dipole s.w.r. What's it like?

Trap antennas are normally pruned to frequency and overall performance is checked by means of a standing wave ratio (s.w.r.) bridge. However, traps and trap antennas may be fine-tuned to resonance using an antenna noise bridge such as the Palomar Engineers unit shown here. The bridge will give a null on each band that the trap dipole resonates on, resistance and reactance can be measured, and wire sections adjusted as necessary to produce the desired resonance points. Other uses for the bridge arond the hamshack include beam antenna adjustment, determination of the resonant frequency of tuned circuits, measurement of the velocity factor of solid-dielectric cables (such as coax), and determining inductance and capacitance. It's even possible to use the noise bridge to tune a transmatch without applying r.f. from the transmitter! (Photo courtesy Palomar Engineers)

2. A trap- or base-loaded vertical in the backyard, on the roof, or on top of the tower used for his 10- and 20-meter monobanders.

3. A gamma-match to the beam tower, tuning *it* up on 80 and 40.

4. An inverted-L or "T" singlewire antenna fed against ground, supported in part by the tower or mast.

Incidentally, the ARRL *Antenna Book* has a whole chapter (No. 10) devoted exclusively to information on restricted space and indoor antennas. The same book has some excellent suggestions for space-saving 160-meter antennas that can be scaled down for 80 and 40 meters with little more than the help of a pocket calculator.

The Trap: Parting Comments

That does it for this month's column. We featured the trap dipole, pointing clearly to the fact that it can be an excellent choice for the space-limited amateur who wants to operate on several bands with but one coax-fed antenna. We highlighted the "why's" behind the trap, described how it works, hit some important installation considerations. There's no question but that the trap dipole can be made to perform a maxi-job in a mini-space. And its automatic band-switching is made to order for modern solid-state rigs.

See you next month.

73, Karl, W8FX

Bibliography

Some pertinent source materials and an extended discussion of the trap antenna topics covered in this month's column can be found in the references listed below. These are all in addition to the standard amateur radio and antenna texts.

1. Althouse, Jack, K6NY. "Antenna Tuning with a Noise Bridge," *Ham Radio Horizons*, November 1978.

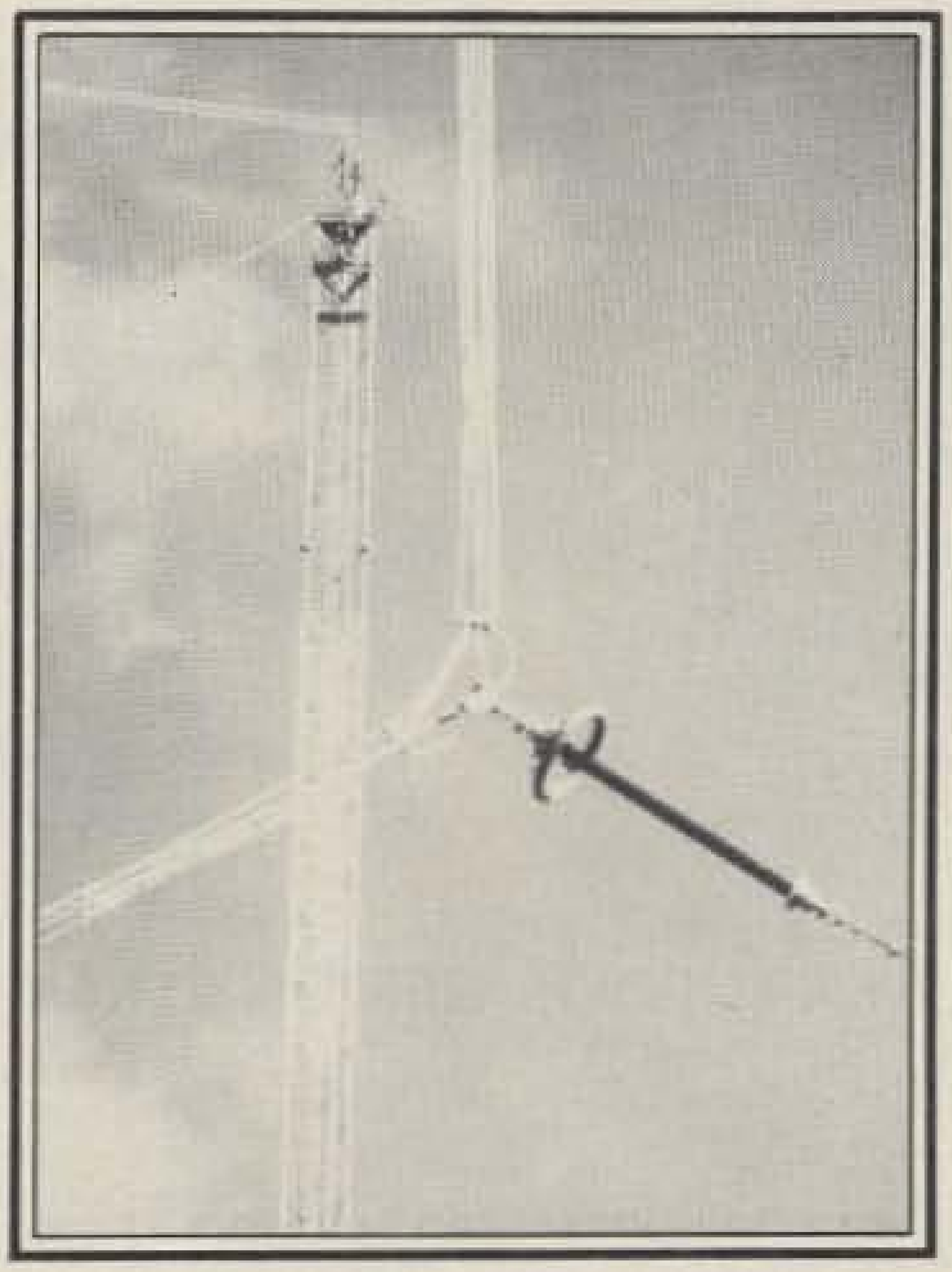
2. Bell, Wesley M., W7QB. "A Trap Collinear Antenna," *QST*, August 1963.
3. Boyer, Joseph M., W6UYH. "The Multi-Band Trap Antenna," in four parts, *CQ Magazine*, February-May 1977.
4. Buchanan, Chester, W3DZZ. "The Multimatch Antenna System," *QST*, March 1955.
5. Cornell, Ken. "A Mini Multi-band Antenna for Mini Real Estate," *CQ Magazine*, July 1976.
6. Cousins, George, VE1TG. "Antennas for Novices, Technicians and SWL's," *Popular Electronics*, May 1968.
7. Fisk, Jim, W1HR. "Simple Dipole Antennas," *Ham Radio Horizons*, January 1978.
8. McCoy, Lew, W1ICP. "Some Basic Antenna Information," *QST*, April 1977.
9. Steckler, Hank, K2OT. "A Single Wire Antenna for 160, 80 and 40 Meters," *CQ Magazine*, January 1978.
10. Thurber, Karl T., W8FX. "All About Traps and Trap Antennas," *Ham Radio*, August 1979.
11. "Useful Information on Multi-Band 'Trap' Antennas," an advertising booklet published by Western Radio Electronics, P.O. Box 400, Kearney, NE 68847. (Contains a wealth of trap antenna information written at the practical level.)
12. Wilson, Alfred, W6NIF. "Trap Yagi Antennas," *Ham Radio Horizons*, June 1980.

Antenna Of The Month

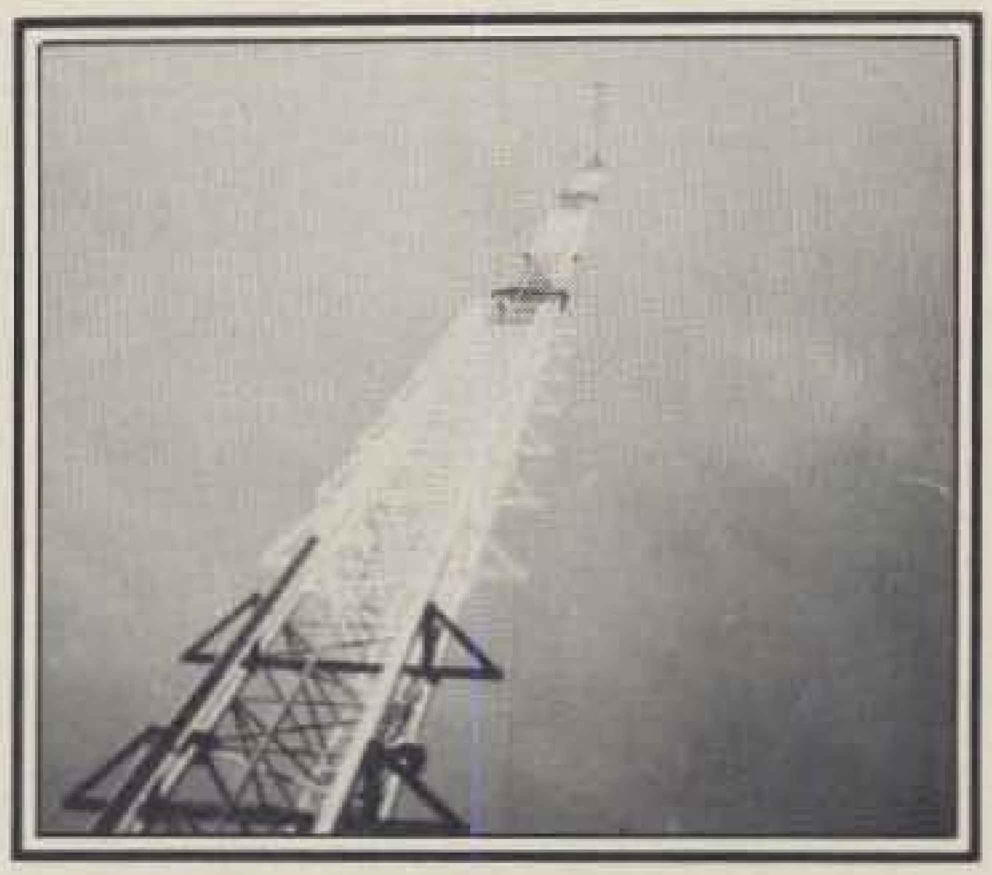
This time we depart from our practice of highlighting a popular commercial antenna. Instead we take a look at the low-frequency (l.f.) antennas at the National Bureau of Standards (NBS) site near Fort Collins, Colorado, home of familiar timeticker WWV. These antennas, however, belong to the l.f. stations WWVL, which though now deactivated, operated on 20 kHz, and sister station WWVB, holding forth with special-purpose time and frequency information on 60 kHz.

As can be seen from the photos, the 400-foot top-loaded towers are something to behold. The antennas themselves are free-floating and completely insulated from the towers. Electrically speaking, the antennas act as high-Q capacitors which are tuned to the extremely low operating frequencies with large coils. The 13 kw, 60 kHz WWVB puts in a good signal to most parts of the continental U.S.A., day and night—at least 100 microvolts/meter to most areas, according to the NBS.

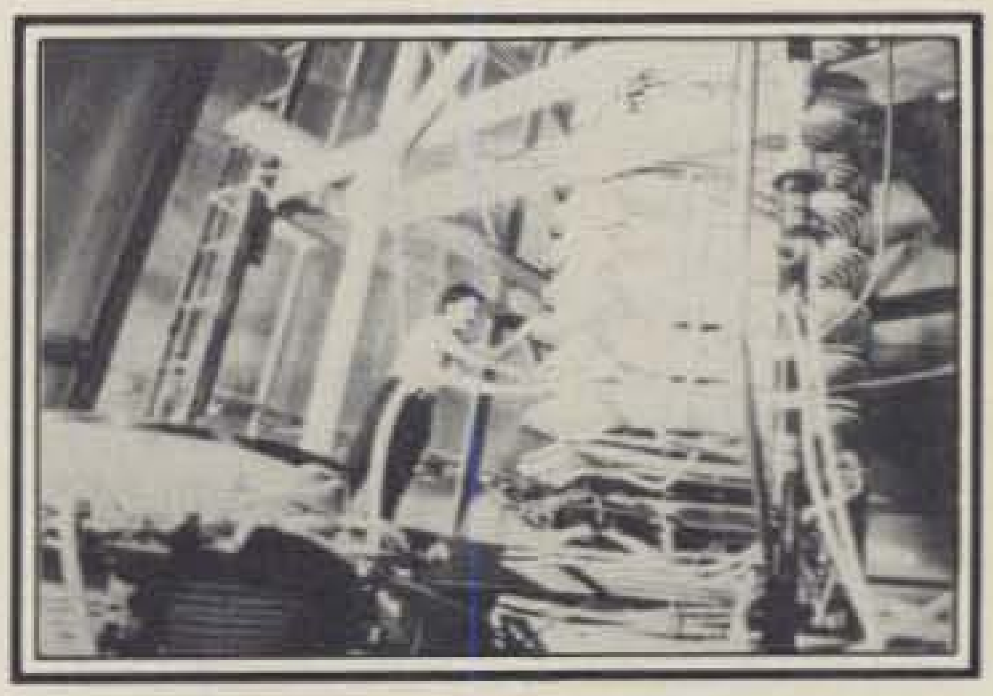
Interestingly, a number of l.f. and v.l.f. time-and-frequency stations presently operate around the world. They are rapidly replacing their h.f. counterparts for ultra-accurate applications that minimize atmospheric distortion of the transmitted signal. Some of the other major low-band stations are as listed in Table 1. Many of them can be received in the United States.



View of one corner of the WWVB/WWVL antenna spans. The systems, identical though used on very different frequencies, are made of four huskily-guyed steel towers which are arranged into a diamond shape, 1900 feet in length and 750 feet in width. Counterbalances are used on the inside and base of each tower to help maintain proper tension at the tops of the towers—neccessary because of the high winds whipping out of the nearby Rocky Mountains. Note the free-floating characteristic. The WWVL antenna has a "Q" factor of about 1,000, while the WWVB radiator's is much lower, around 100. Interestingly, WWVB began experimental broadcasts in 1956 using the callsign KK2XEI and is still operating today, with an ERP (effective radiated power) of 13 kw. WWVL first went on the air in 1960 but ceased broadcasts in 1972 except on a very limited basis.



Shown here is one of the 400-foot WWVB and WWVL antenna towers; the antennas are identical, and are top-loaded. Both stations are sister installations to the familiar h.f. time-ticker, WWV, though the 20 kHz WWVL transmitter has not been on the air regularly since 1972. The 60 kHz WWVB station is extensively used, however, to provide good coverage of the entire continental U.S.A. with precise time and frequency data much in the same way that WWV provides consumer-type calibration information on popular h.f. frequencies (5, 10, 15 MHz, etc.). The bandwidth of the WWVB antenna is about 600 Hz, while the bandwidth of the WWVL antenna is but 20 Hz! Not surprisingly, efficiencies are low; 35% for the 60 kHz WWVB antenna and 5% for the 20 kHz WWVL antenna. Shades of 75-meter mobile operation!



R.f. hardware at v.l.f. frequencies is Texas-size, to say the least. Photo of the antenna coils in the "helix house" at WWVL dwarfs the worker in the center of the photo. WWVL's transmissions were curtailed in 1972, although the station and the antennas are still in place at last report, and they are occasionally tested and used by various government agencies on a subscription basis. Crystal-controlled oscillators were used in the transmitter to generate the carrier wave. One, two, or three operating frequencies could be chosen: 19.9, 20.0 or 20.9 kHz; or all three could be transmitted simultaneously. Sister station WWVB is still on the air on 60 kHz, carrying high-precision, low-frequency time and frequency data.

Callsign	Location	Frequency (kHz)
RTZ	Irkutsk, USSR	50
RBU	Moscow, USSR	66.67
GBR	Rugby, England	16
HBG	Prangins, Switzerland	75
JJF-2	Chiba, Japan	40
DCF77	Mainflingen, Germany	77.5
WWVB	Colorado (USA)	60
MSF	Rugby, England	60
OMA	Prague, Czechoslovakia	50

Table 1–Major low-band stations.

a monthly feature by
KARL T. THURBER, JR., W8FX

Antennas

DESIGN, CONSTRUCTION, FACT, AND EVEN SOME FICTION

A Look At The Longwire (Part I)

We've pretty much "run the gamut" of wire antennas. We have looked at dipoles of most every description, Zepps, Windoms, tuned-feeder types, and more. So, far we've touched only lightly on the longwire— and for good reason. It's a very confused and confusing area of antenna lore, but one that we should be able to straighten out without too much difficulty.

We can't possibly cover *all* the different types of longwires—that's book-length material. But we can highlight singlewire and randomwire antennas, center- and unsymmetrically-fed longwires, and long end-fed Zepps. Next month we'll point out how longwires can be used on the v.h.f. and u.h.f. bands, and we'll review some important feed considerations.

Let's turn first to the terminology of longwires and related antennas.

Longwire Lingo

First, a *true longwire* is a wire antenna at least several wavelengths long, supported on each end. The longer the antenna, the greater the directionality and gain. This type of antenna is frequently confused with *singlewire* and *randomwire* types. A wire antenna doesn't qualify as a longwire unless it is, in fact, **long** in terms of the operating wavelength. At 80 meters, for example, we're talking in terms of flattop lengths of about 750 feet or more (three wavelengths).

So, then, what is a **singlewire**? This is a direct-fed antenna, in which the return circuit for the system is the earth. We're really describing the *method of feed* when we cite the singlewire, but, in effect, with this kind of antenna, the transmission line and antenna are as one. A singlewire may be a longwire, *too,* if it's really long,

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Longwire antenna adjustment can be painstaking is optimum performance is desired. The antenna should be trimmed carefully to resonance and the feedpoint impedance checked for a good match to the transmission line. The r.f. noise bridge facilitates making antenna adjustments of the kind that s.w.r. bridges only indirectly measure. The MFJ instrument pictured allows measurement of resonant frequencies, radiation resistance, and reactances. Working over the range 1 to 100 MHz, the device enables one to determine whether to lengthen or shorten the antenna for minimum s.w.r. (Photo courtesy MFJ Enterprises, Inc.)

but all longwires aren't necessarily singlewires, since many are fed with parallel-conductor feeders or even coax, if routed through a matching device such as a balun.

The **randomwire** is just what the name implies. It's an *antenna of chance*, usually of singlewire construction, of any convenient length and driven by the transmitter or fed through an antenna coupler or matching circuit. It, too, may be a longwire, but *only* if it's in fact long.

While these terms are used so interchangeably as to create new synonyms, mixing them up makes it more difficult to understand the basic distinctions between these antenna types.

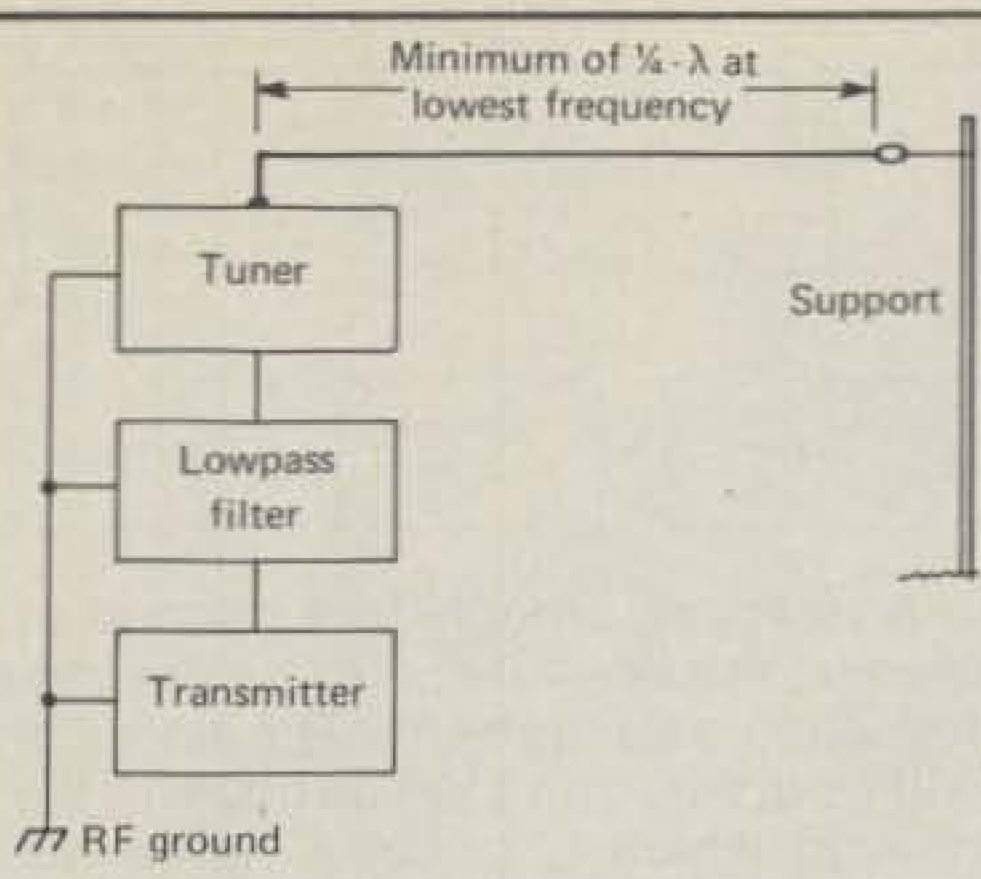
Popular Longwire Types

When we speak of the longwire family, we are concerned mainly with four types: (1) long antennas of chance, such as the randomwire and singlewire; (2) centerfed longwires, essentially extra-long dipoles; (3) unsymmetrically fed longwires, sometimes called off-centerfed Hertzes; and (4) end-fed types, closely related to the classic Zepp antennas of airship fame.

All four types are capable of yielding substantial gains over the basic dipole, especially when very long. A 3-wavelength longwire will show slightly less than 2.5 dB gain on the major lobes. A 6-wavelength flattop shows 5 dB gain, and a 15-wavelength long-longwire exhibits 10 dB gain. Generally speaking, maximum radiation occurs about 45° off the wire's axis. As the antenna is made longer, the greater the number of horizontal lobes and the more directional the antenna becomes off the ends. The radiation pattern of the centerfed longwire is symmetrical, but off-centerfed and longwire types are more directional in the direction of the long leg. Radiation angle depends on the antenna height above ground; it will be lower (favorable for DX) for antennas that are high with respect to wavelength.

Let's look at each of the four main types in turn.

Long antennas of chance. We are speaking here of two antennas that are as old as the hills: the singlewire and randomwire types, shown in fig. 1. Though feeding and matching are sometimes tricky, they often work amazingly well. Almost anything has been used as antennas, including rain gutters, metal windowsill frames, wires strung from ceilings, bedsprings—you name it. Often these antennas are erected when there is no



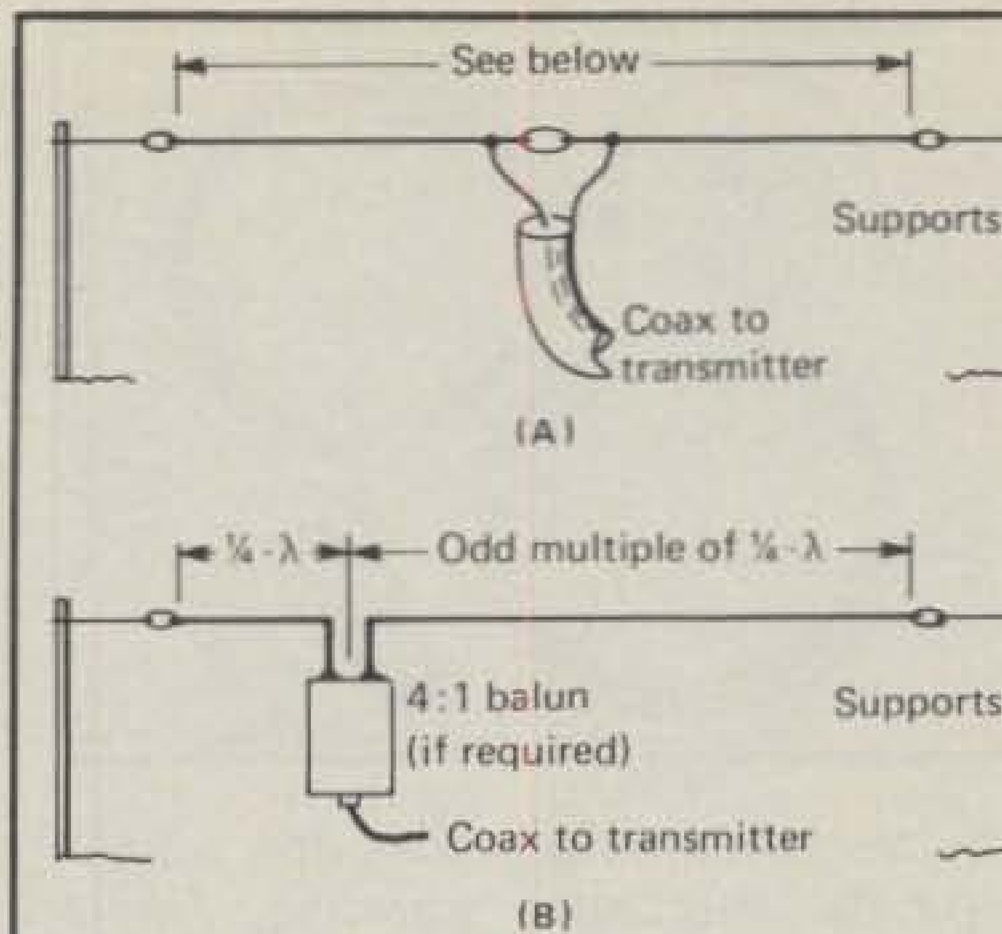
Singlewires and randomwires are birds of a feather, though they are not exactly synonymous. Both are considered to be antennas of chance, since their fed-against-ground, often causual constructions may make feeding and matching difficult and tricky.

One of the easiest antennas to set up is the direct-fed randomwire, which is of any convenient length and connected directly to the transmitter's or transmatch's output terminal. The length of wire used should be a minimum of one-quarter wavelength at the lowest frequency band to be used.

Loading will be best when the total wire length isn't really random, but is instead an odd multiple of a quarter-wavelength on the favorite band to be used. This allows the antenna to present a low impedance to the tuner.

As with all single-wire fed antennas, the ground system plays a very important part and if inadequate can cause substantial signal loss.

Fig. 1– Chance-fed antenna configurations.



(A) Long centerfed, single-band dipoles are good candidates for direct coax feed. And, it turns out that an antenna length of 112 feet is a good compromise dimension for work on both 10 and 15 meters. For all-band work, 135-foot flattops are popular, though the antenna will not behave as a true longwire on those bands where its legs are even multiples of quarter wavelengths; feedpoint impedance will be high on those bands.

(B) Connecting the feeder ¼-wavelength in from one end allows low-impedance feed; the long end can be any odd multiple of a quarter wavelength. Direct coaxial feed is possible if operation is limited to a single band and if the antenna isn't terribly long in terms of wavelength. Extremely long antennas of this type will exhibit somewhat higher feed impedance and require parallel-conductor feedline or the use of a balun transformer.

Fig. 2– Centerfed and unsymmetrically-fed longwire antennas.

hope of stringing a precisely measured and accurately fed flattop, such as in some landlord-restricted apartments, condominiums, and in vacation and portable work. The basic rule of thumb is, if you can get your transmitter to load, with or without the use of a transmatch, try it if it's the only way to get on the air.

Perhaps the easiest antenna to install is the *randomwire*, which can be of any convenient length depending on the space available. Called a direct-fed antenna, the flattop and feedline are as one, being connected directly to the output terminal of the transmitter or antenna coupler. The problem here is that it's hard to predict what the impedance will be at the transmitter. This will vary for each band, and on some bands awkward impedances will be presented which may make loading difficult even when using a transmatch. With a wide-range tuner, it will probably be possible for the antenna to be loaded up on all bands unless the antenna is very short, say less than about 1/8-wavelength. This would make about 32 feet the shortest wire that should be used if all-band (80–10 meter) operation is planned. Shorter lengths, in addition to being hard to load, will likely be poor performers. Generally speaking, it's preferable to bend the antenna to use a full-length flattop.

The randomwire should be erected as high and as free from obstructions such as telephone and power wires as possible. It should be supported by two poles, or by a pole and a tree, and isolated from the supports by means of insulators. The antenna itself is usually made of No. 12 or 14 copper wire. The feeder portion (not a true transmission line) should be of heavy insulated wire, and it should not come in contact with the house or antenna supports. Flexible plastic tubing can be slipped over the wire where it passes through walls or windows.

Amateurs who have landlord problems report good results using very fine wire, No. 30 or even smaller. Very small-diameter wire is practically invisible when strung high in the air. Small buttons or even rubber bands have been used for supports and insulators.

While many randomwire enthusiasts follow the old maxim that the more wire in the air, the better, certain lengths will give more consistent results, reducing the element of chance. The antenna can be cut for a ½- or ¼-wavelangth at the lowest frequency to be used, either 67 or 135 feet for 80–10 meters. You can minimize "r.f. in the shack" problems by having a current loop occur on your favorite band or bands at the transmitter end. Thus, a ¼-wave wire length or *odd* multiple thereof would be desirable from this standpoint. This would work out to about 65 feet on 80 or 33 feet on 40, or odd multiples of these lengths.

A good r.f. ground system is important, lest a good deal of power be lost via the ground path. Some experimentation with the ground will almost certainly be required. Try using cold water pipes that are known to be earth-grounded, outdoor ground rods, buried radials, indoor counterpoises (¼-wavelength sections of insulated wire), and various combinations of these grounds. The ground run length will modify the antenna's effective length and impedance characteristics.

Centerfed longwires. In an earlier column, we described the basic centerfed dipole and several variations, including the extended double Zepp and multiband versions. We'll piggyback on these in covering longwires.

We're partial to the centerfed antenna; it's just a neater overall system, in my book. A low impedance feedpoint can be had by making each leg an *odd* multiple of a quarter wavelength. This, for example, allows the ordinary 40-meter dipole to be fed easily with low-impedance coax on 15 meters, though the antenna only minimally qualifies as a longwire.

For single-band work, a centerfed longwire is a good candidate for direct coax feed, though some tweaking using an antenna noise bridge or s.w.r. meter may be necessary to get the antenna exactly resonant. An antenna length of 112 feet (56 feet on a leg) is popular for dual-band 10/15 meter

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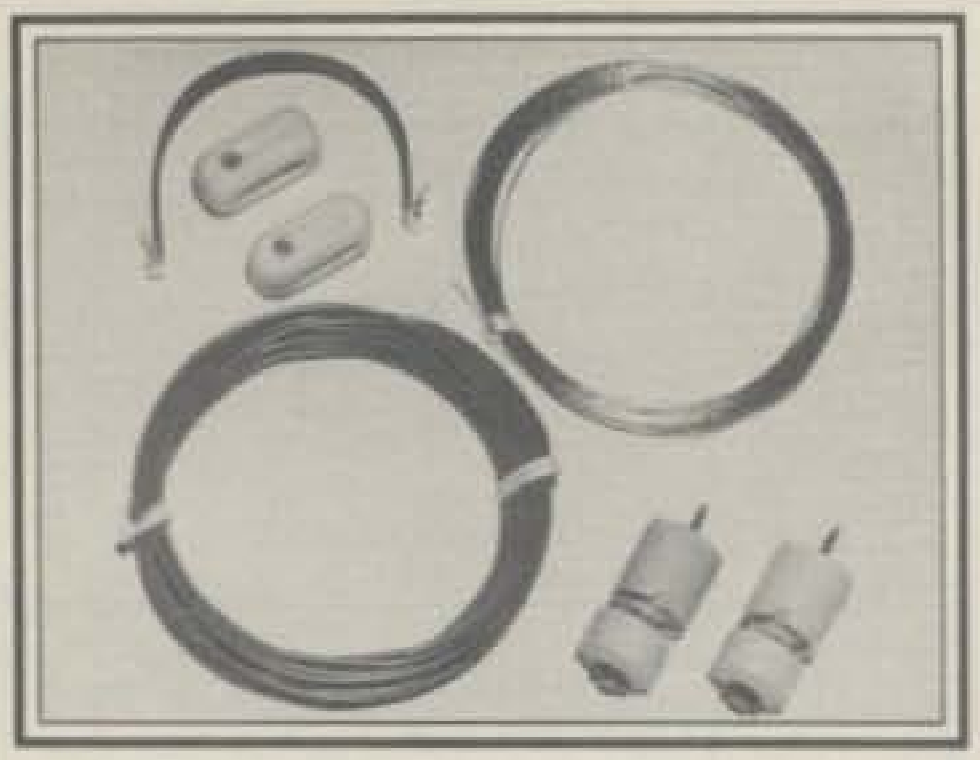

The basic building blocks of a receiving-type shortwave antenna. Radio Shack kit is complete and includes 75 feet of stranded copper antenna wire, 50 feet of insulated singlewire leadin, an insulated window feedthrough with Fahnestock-type clips, standoff insulators, and instructions. Such an antenna would not be suitable for transmitting except in very low-power (QRP) applications. (Photo courtesy Radio Shack)

work. The antenna works out to be a 2½-wavelength skyhook on 15 and a 3½-wavelength radiator on 10 meters, with a symmetrical radiation pattern strongest about 45 degrees off the wire axis.

For all-band work, a flattop of 135 feet works well. And a 67-foot length should give good results on 40 through 10, if fed with an open-wire line as described in an earlier column. However, the antenna will not strictly act as a longwire on those bands where its legs are even multiples of quarter wavelengths, and feedpoint impedance will be high. Thus, some of the advantages of center feed melt away where the antenna is operated in the multiband mode. Unsymmetrically- and end-fed versions hold much promise, however.

Unsymmetrically-fed longwires. The longwire antenna can be conveniently fed at a low impedance point. This means connecting the feeder a quarter wavelength in from one end. The long end can be any desired odd multiple of a quarter wavelength. For antennas not terribly long with respect to wavelength, it's possible to directly feed the antenna with coaxial cable, though the feedpoint impedance will be somewhat higher than the usual 70–75 ohms. For longer antennas, a 4:1 balun can be used at the antenna to effect an impedance transformation to yield a satisfactory match to coax. Alternately, the antenna can be fed with open-wire line.

This type of longwire is an essentially single-band affair. However, if you can erect the antenna so as to be able to easily get to it to make adjustments, it may be worthwhile to design it for multiband operation. This can be done by segmenting the antenna and using fixed insulators and alligator clips to clip-in the required quarter-wave sections on the short side, and the longer sections on the long side. Though a pain to adjust each time when changing bands, the antenna has some advantages: it's preset to frequency on each band, the patterns are predictable, and it can be fed with coax through a balun.

Fig. 2 shows typical centerfed and unsymmetrically-fed longwires.

End-fed versions. Probably the best all-around way to achieve true longwire operation on all bands is to use the end-fed Zepp, in which a single flattop is fed at one end by open-wire line. The antenna will work well on all bands down to the one at which the antenna is but a half-wavelength long. Any convenient line length can be used if a wide-range transmatch is employed at the transmitter end.

As with all end-fed antennas, the system—though convenient—usually suffers from considerable antenna current on the line, feeder unbalance and line radiation, with resultant antenna pattern distortion. The Zepp's normal radiation pattern will change as the wire is made longer relative to wavelength, though maximum radiation will still occur at about 45 degrees off the ends of the wire. Radiation angle will be lower as the antenna height is increased, in common with other horizontal antennas. High mounting provides a low vertical angle for DX work.

A balun provides smooth electrical transition between the unbalanced mode of coaxial cable and the balanced mode of the antenna. Without the balun, this change is abrupt and pattern-distorting and TVI-inducing currents can be set up on the outside of the coax. The balun shown here is a 1:1 model; a 4:1 impedance-transforming balun is often used to feed the longwire with coax. (Photo courtesy Unadilla/Reyco)

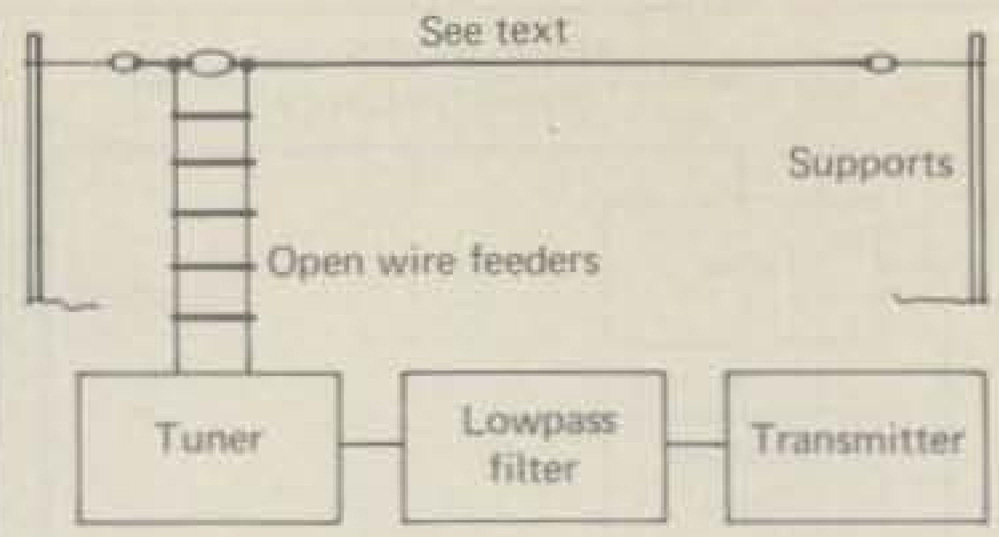

Fig. 3– A method of end-feeding the longwire antenna.

A relatively trouble-free method of feeding the longwire is to use the end-fed Zepp arrangement. The antenna will work well on all bands down to the one on which it is but a half-wavelength. Although the antenna is cut in most cases for some multiple of the wavelength of the lowest band to be used, any length of wire can be used. Best results are attained using low-loss open-wire feeders routed through a wide-range transmatch.

Fig. 3 shows end-fed longwire configurations.

So far, we have dwelled on the three most common h.f. longwire configurations. There are many others, more complicated types that allow modification of the directivity pattern and increased gain. These sophisticated types include parallel longwires, multiple longwire Vee beams, resonant and nonresonant rhombics, and very *long* longwires. Space doesn't allow us to cover these now.

(To be continued)

Murch high-power antenna tuner is of the classic "ultimate transmatch" design pioneered by ARRL staffer Lew McCoy. It is particularly suited to loading up longwires fed with parallel-conductor (open-wire) transmission line, and it contains a built-in three-core balun. The unit will also accommodate other antennas, such as ordinary dipoles, randomwires, verticals, whips, and beams. (Photo courtesy Murch Electronics)

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Antennas

DESIGN, CONSTRUCTION, FACT, AND EVEN SOME FICTION

Antennas For The Listener: Part I

"What?" you say. Shortwave antennas on the pages of CQ Magazine, the Radio Amateur's Journal? *Yes, and for several reasons. Many s.w.l.'s* do *read* CQ, *since a good deal of the information in the magazine is transferable to shortwave doings. And, after all, receiving* is *half the two-way communications equation. Also, many longtime hams are shortwave listeners at heart; you will discover that W8FX is one too!*

A listening antenna can be just about anything: a small loop or telescoping whip atop the receiver, a wire hung out of a window, a few yards of bell wire stapled to a picture molding, a window screen or bedspring—you name it. Almost anything and everything has been used.

While the simpler antennas may be fine for casual listening to strong shortwave signals—being a lot more forgiving of poor installation than their transmitting counterparts—simple types leave a lot to be desired. Even the finest receiver works better with a well-designed, preferably outdoor, antenna.

This month, then, we begin a series on listening antennas. We will consider basic types such as the randomwire, dipole, and vertical antennas. Next month, we'll introduce some interesting and useful tuneup aids.

The Randomwire Revisited

In a recent column, we described the randomwire and closely related "antennas of chance," such as the singlewire, longwire, Windom, etc. We don't want to get hung up on terminology; suffice it to say that, regardless of feedline used, most of these antennas are truly random in nature since they are rarely cut for optimum performance on a given band, and as listening antennas, they are usually used on more than one band, anyway.

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For the travelin' ham who is used to communications receiver quality, new-breed digital portables such as the Panasonic RF-2900 shown here have much to offer. Set covers five bands, including three SW ranges from 3.2 to 30 MHz continuously, features double conversion superhet circuitry, and boasts 5-digit readout. The 8-pound 10-ounce set has a dual-bandwidth ceramic i.f. filter and includes a BFO for c.w. and s.s.b. reception. (Photo courtesy Panasonic.)

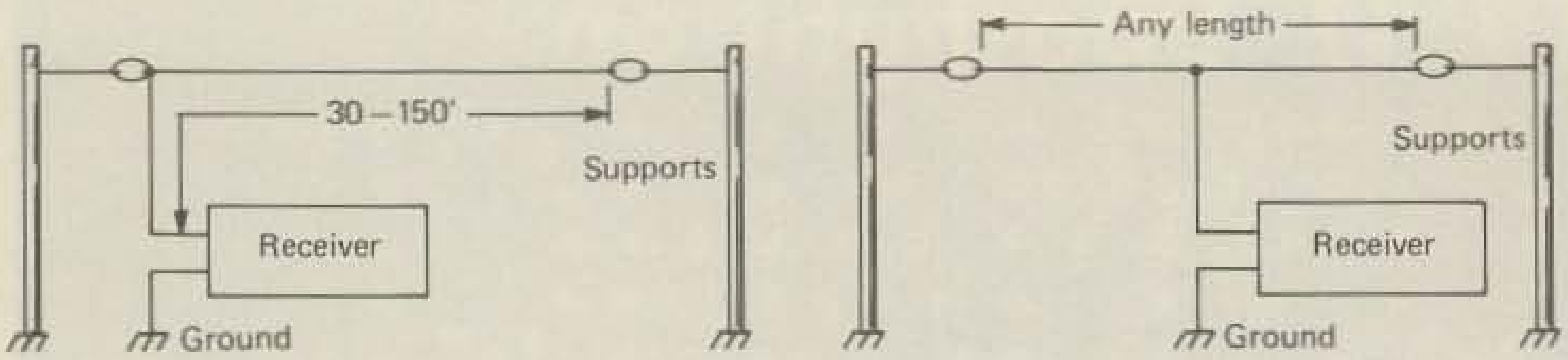
Probably more s.w.l.'s use the end-fed randomwire (fig. 1) than any other type of antenna. The flattop can be of any convenient length, usually from 30 to 150 feet; normally, the vertical lead-in that runs down from the antenna to the house is an *active part* of the antenna system and must be considered integral to it. As a rule, the longer the antenna, high and in the clear, the better; very long antennas may take on tricky directional characteristics that prove undesirable on the higher bands, while extremely short antennas may not develop enough signal pickup on the lower ranges. The antenna and its feedline should be located well clear of possible interference sources such as power lines and busy thoroughfares. Avoid crossing under or over power lines and never attach one end to a power pole. *Play it safe!*

The antenna must be insulated from its supports at each end using glass or porcelain insulators. The lead-in, actually a part of the antenna, should be held a few inches from the house using TV or electrical-type standoffs. Keep the lead-in away from metal objects and power cords in your radio shack.

As with any singlewire, this kind of antenna works best when used in conjunction with a good ground system. A short, heavy wire should be run from the receiver (and antenna tuner, if used) to the nearest r.f. ground. This can be a metal grounding rod driven into the earth at the point where the antenna comes inside or a cold water pipe that has a direct connection to ground. Simply running a wire to the faceplate of the electrical outlet in the radio shack isn't good enough; this may be a good *electrical* ground, but a very poor one for *r.f.*

The antenna should also be protected against lightning strikes and static discharges. A commercial lightning arrestor can be installed, or one can be constructed from a few simple parts. In any case, it should be located outside the house and a direct connection made to the outdoor ground. A heavy grounding switch can also be used.

In that the end-fed randomwire's feedline is an integral part of the antenna; the antenna usually takes on the physical appearance of an upside-down letter "L." As a result, it's often known as an *inverted L.* In practice, the feedline can be connected to any convenient point on the flattop span, if the available supports for the antenna are more favorable for a center-fed or off-center-fed lead-in. Let the shape of your property, the location of your house on it, and the locations of suitable supporting trees determine where you connect the feedline. If fed



The randomwire, as shown above, is perhaps the simplest of all antennas to install. Normally 30–150 feet long, its effective length includes the feedline; an antenna tuner is almost mandatory for good results. Installed normally as an inverted-L (above), it may also be formed into the shape of a "T" or even erected vertically for onmidirectional coverage. The Windom, or off-center-fed arrangement, can also be used, although this is not strictly a randomwire, since it is cut for optimum performance on a specific band or group of bands.

Fig. 1– The randomwire for all-band shortwave use.

in the center, the antenna may be called a "T," and if fed off-center, a Windom. Unlike the "L" and "T," which probably work about equally well on all the SW bands, the Windom works best on the band for which it was designed, or over a certain group of bands. Normally, this antenna is cut for one-half wavelength on the primary band of interest (fig. 2) and fed at a point about one-third in from the end. Alhough its performance is optimized for a single band, it will also work fairly well on the other SW bands.

Although most receivers will work reasonably well with any kind of antenna system connected to its antenna terminals and will tolerate almost any degree of mismatch, randomwire performance will be a good deal better if the antenna is fed through a tuner to allow the system to be resonated and matched to the receiver's input impedance. More on this later.

For the beginner, companies like Radio Shack and several *CQ* advertisers sell simple and inexpensive s.w.l. antenna kits. They are especially designed for beginners.

Dipoles On The Shortwaves

The randomwire is popular because it produces reasonably good results over a wide range of frequencies; it's forgiving of the most serious off-band use and impedance variations since these things can be compensated for by a good wide-range antenna tuner.

On the other hand, the dipole is designed to be used on a specific, single band (with a few exceptions). A dipole cut for one band usually won't do well on other bands. However, on the band for which it's cut, it's a superior performer for a number of reasons: its reception pattern is predictable (broadside to its length); it's resonant and has a known feedpoint impedance, meaning that easy-to-handle coaxial cable can be used to feed it; and its construction lends itself to center-supported DX versions, including the Vee and inverted-Vee.

For broadband performance an improved version is the *folded dipole*. In one popular design, both the flattop and the lead-in are made from common (and inexpensive) TV-type lead-in with the flattop cut to the standard dipole formula length of

$$L \text{ (in feet)} = \frac{468}{f(\text{MHz})}.$$

At the midpoint of the span, *only one* of the two wires of the twinlead is cut. The feedline is connected to each side of the cut as in the simple dipole. The two wires of the twinlead that make up the flattop should be twisted together and soldered at each end. The folded dipole should yield especially good results over the wider shortwave bands. Since its resonance curve is a broad one, it's very tolerant of off-frequency use. Nevertheless, the fact remains that both types of dipole are single-band affairs. This is true with the exception of dipoles used on *odd-harmonics* of the design frequency, such as a 41-meter dipole used on 13 meters.

Dipoles can also be constructed *in parallel* and fed with a single transmission line, as described in an earlier column. Although a mechanical problem to construct, this design allows one to use individual dipoles for each of the popular SW bands and get near-optimum performance on each. If a high center support is available, the multiple dipoles can be fanned out in a turnstile or spokes-of-a-wheel arrangement for easier installation and omnidirectional coverage.

Another way to obtain multiband performance in a dipole is to install traps in the flattop to electrically isolate each band's half-wave dipole from adjacent sections; this allows each section to function as a dipole on each band of interest. The traps may be homebrewed or purchased commercially. Western Radio Electronics (Kearney, NE 68847) sells a 65-foot, 6-band horizontal trap antenna that is designed for use on the 49- through 13-meter SW bands using two traps and fed with either 72-ohm twinline or

As with amateur-band antennas, optimum performance can usually be obtained if the antenna is cut to frequency, or close to it. The table below lists approximate half-wave dipole lengths according to the formula $L(\text{feet}) = \frac{468}{f(\text{MHz})}$

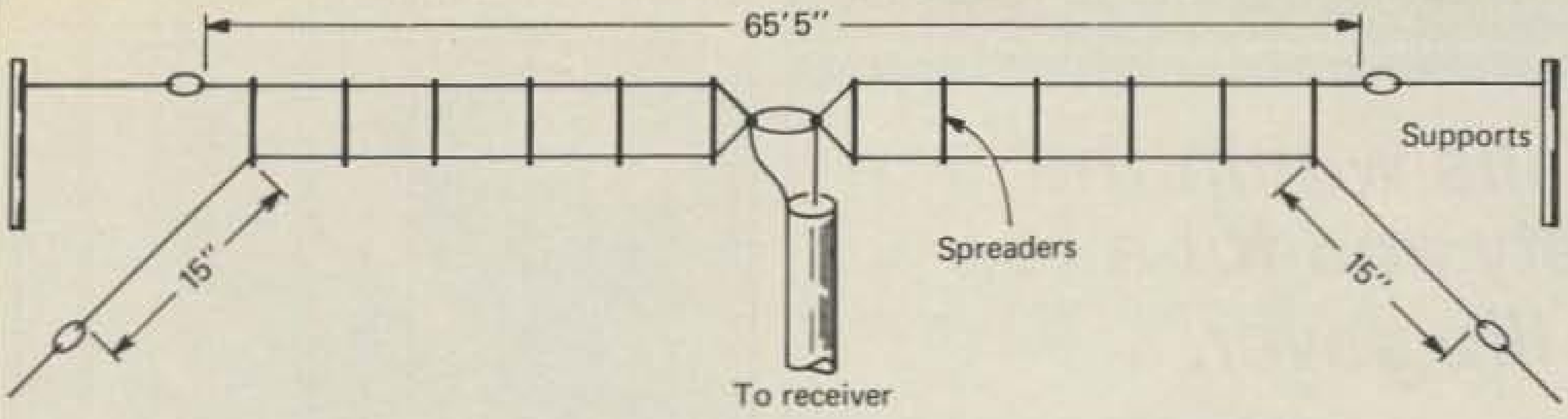
Shortwave band (meters)	Nominal range (MHz)	Dimension (feet)
11	25.6–26.1	18
13	21.45–21.75	21′8″
16	17.7–17.9	26′4″
19	15.1–15.45	30′6″
25	11.7–11.975	40′
31	9.5–9.725	49′
41	7.1–7.3	65′5″
49	5.95–6.2	78′
60	4.75–5.06	95′6″
75	3.9–4.0	118′6″
90	3.2–3.4	141′10″
120	2.3–2.5	195′

The doublet or dipole should be hung as high as possible, although it may be installed indoors (taped to walls or under a rug) if necessary. Ideally, it should be hung outdoors between two tall trees with the coax run away from the antenna at a right angle directly to the radio shack.

The antenna will work most efficiently on the center frequency of the band for which it is cut, but in practice it will work well across the entire band. Although instruments such as the antenna noise bridge (ANB) may be used to achieve exact resonance, this is not necessary in receiving antennas.

The dipoles may be used on other bands with some reduction in performance. This will be especially noticeable if shorter (higher frequency) antennas are used on the lower bands.

Fig. 2– Dipole antenna dimensions for the shortwave bands.

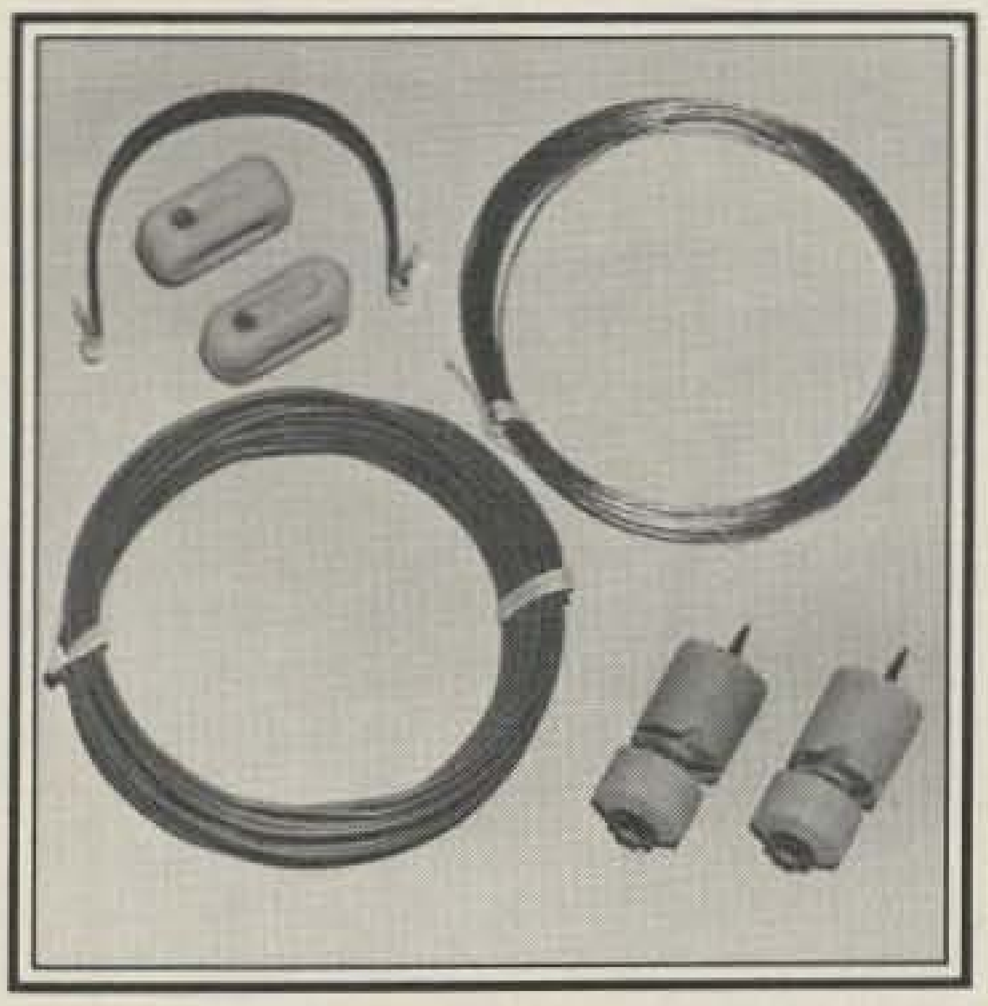


The antenna shown above is a simple parallel dipole that resonates in or very close to four of the major international shortwave broadcast bands. The antenna consist of two dipoles, one 65′5″ long that resonates on 41 meters, and a longer one of 95′6″ that is resonant on the 60-meter band. Since the dipole works well on odd harmonics of the design frequency, the 41-meter dipole will yield good results on the 13-meter band, while the 60-meter span will give a good account of itself on 19 meters.

The antenna can be cannibalized from a length of 300- to 600-ohm TV or open-wire transmitting-type transmission line; it can also be made of ordinary antenna wire with lightweight spreader bars inserted at appropriate points to keep the wires from coming into contact with one another. TV twinline can even be used for the center portion, if desired. The ends can be drooped down as shown in the sketch to conserve horizontal space, or run straightaway if room exists.

The four-band affair can be fed with coaxial cable as shown, or with 72-ohm twinline. Lightning protection should be provided.

Fig. 3– Efficient four-in-one SWL antenna.

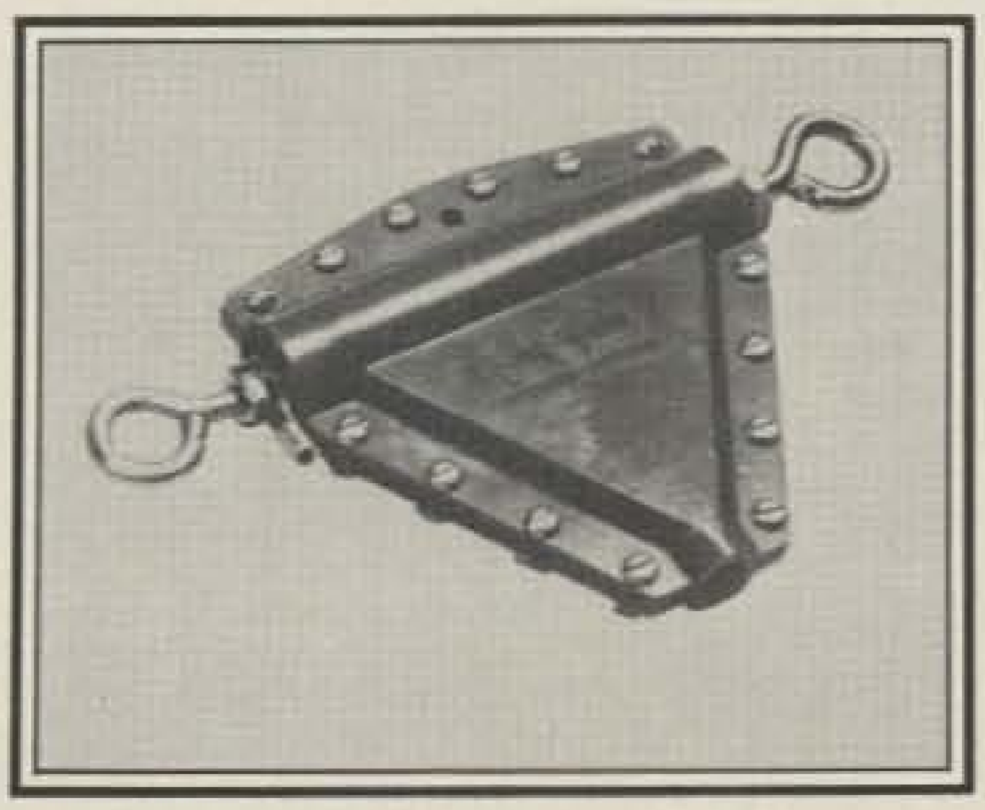


The basic ingredients of the simple singlewire antenna: 75′ antenna wire, lead-in, window feed-through strap, end insulators, and standoffs. Complete outfit is sold by Radio Shack stores for under $8. (Photo courtesy Radio Shack.)

coaxial cable. A shorter, 37-foot version is available that covers 31 through 13 meters. Since only two traps are used, these antennas operate on multiple-harmonic relationships on the higher bands to produce a cloverleaf-shaped reception pattern and some gain on these bands. The antennas are fed at current points to allow low-impedance feed and resultant low s.w.r. An antenna tuner is not required to match the trap antenna to the receiver, although one may be used if desired. The same firm also sells single-band dipole kits made to order for each of the popular SW and amateur bands. Dentron, for example, sells an all-band, tuned-feeder doublet kit; although designed for transmitting use, it can be used on any frequency from 160 through 10 meters when fed through a transmatch designed to accommodate balanced feedline.

Verticals

The vertical is a logical choice when space is at a premium and when good DX performance is a must. The vertical has a low angle of radiation and reception, it can be mounted on the ground or in the air (as a ground plane), and it can be directly fed with coaxial cable. One disadvantage is that it must be worked against a very good ground system for reasonable efficiency (though a poor ground would not affect receiving nearly so much as it would transmitting). Also, the antenna's low angle of radiation (or, more properly, *reception*) and vertical polarization make it more susceptible to man-made noise marring reception.



Center insulator for doublet antenna makes for easy installation and feed with coaxial cable. Lightweight Hy-Gain CI insulator is weatherproof, being molded from high impact cycolac material. Unit accepts ¼″ or ¾″ cables (normally the thinner cables would be used in receiving work). (Photo courtesy Hy-Gain Electronics.)

The basic vertical is a quarter-wavelength in height; this works out to about one-half of the dipole lengths indicated in fig. 2. At least four radials are used. If buried, they should be as long as possible and used in conjunction with a ground rod under the antenna. If the antenna is mounted above ground as a so-called *ground-plane vertical*, the four or more radials should each be ¼-wavelength long, plus about 5%. The feedpoint impedance is between 35 and 50 ohms, so a good impedance match should be attained if standard 50-52 ohm cable is used.

The vertical is essentially a single-band affair, like the dipole. However, the antenna can be used on all the SW bands (and lower, if necessary) by installing a loading coil at the base and tapping the coil for best match (or received signal) on the desired band. This type of base loaded antenna can be constructed easily and inexpensively from little more than a few lengths of aluminum tubing and some coil stock.

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Antennas For The Listener: Part II
Tuneup Aids For The Shortwave Antenna

Receiving antenna tuneup is a bit different than for transmitting. First, exact resonance and impedance matching is not as critical in the receiving antenna—which, for practical consideration, is often used for listening on several bands, some of which may be far removed from its actual resonant frequency. Second, on the lower bands, it may be more desirable to have lots of wire in the air to capture weak signals, exact resonance being a secondary consideration. Third, determining resonance and impedance is more difficult on receiving since s.w.r. bridges require a source of r.f. (such as from the transmitter) to activate them. Other instruments, such as the noise bridge or grid-dip oscillator, must be used to make these measurements.

If you've erected a randomwire, there is little point in making adjustments to it—after all, it was randomly installed for compromise performance on all bands. Simply make sure that it is as long and high as possible and that you've attained a good, low-resistance ground connection. A wide-range antenna tuner is a must. One designed especially to handle singlewire feeders should take care of most any impedance variations.

If you've installed a dipole and plan to use it on a particular band (or several bands, if of the trap or parallel-dipole type) then it pays to take the extra time and trouble to check for resonance and feedpoint impedance match. The same goes for the single-band or trap multiband vertical. Even if you're using a manually-adjusted, baseloaded vertical, it's worthwhile to pretune the antenna and note loading coil tap settings for future use in changing bands.

317 Poplar Drive, Millbrook, Alabama 36054

Simple three-knob MFJ "Versa Tuner" antenna coupler, though designed for 200-watt transmitting use, will match almost any kind of antenna to receivers over the range 1.8 to 30 MHz. Containing a built-in 1:4 impedance-transforming balun, the unit is flexible enough to work into dipoles, Vees, verticals, randomwires, beams, balanced/tuned feeders, and coax. (Photo courtesy MFJ Enterprises)

The grid-dip oscillator (GDO) is a simple, reliable and inexpensive instrument that can be used to determine antenna resonant frequency as well as perform a host of other measuring functions, such as assessing transmission line resonance and velocity factor and the values of capacitors and inductors. Since it contains its own low-power r.f. source, it can readily be used to determine receiving antenna resonance. Both dipoles and end-fed Zepps can be checked by bringing the meter up close to the antenna and inductively or capacitively coupling the instrument to it. If you're considering a GDO for purchase, look for one that offers high calibration accuracy, covers a wide frequency range, and is battery-operated so that it can be carried right to the antenna.

An extremely useful instrument to both the s.w.l. and amateur is the antenna noise bridge (ANB). It's actually an updated version of earlier instruments known variously as the antenna bridge, Z-bridge or Antennascope (the latter described in the pages of *CQ Magazine* by inventor Wil Scherer, W2AEF, as early as September of 1950). The big difference between the ANB and other instruments of similar ilk is that it is not only an impedance-measuring device, but it also includes a broadband noise signal source. As a result, the ANB doesn't require an external signal to activate it, such as that from a GDO or a transmitter. This means that as long as you have a communications receiver that tunes the frequency of interest, both antenna resonance and impedance can be determined.

In practice, when using the ANB, the receiver is set to the operating frequency and the ANB is set to the desired impedance. The antenna is adjusted or pruned accordingly until a pronounced noise null is detected, either by ear or on the set's S-meter. If you can stand the surprise (!), the bridge can also be used to determine the actual impedance and resonant frequency of your *existing* antenna. It can also be employed between the antenna coupler and receiver to determine proper tuner settings, as well as to do a host of other neat things, including acting as a signal source for receiver alignment, adjusting bandpass filter circuits, making r.f. gain measurements, and like tasks.

Receivers can benefit from antenna tuners as well as transmitters. This is particularly the case when a randomwire antenna is used or when a resonant antenna (like a dipole) is pressed into service on bands far removed from the design frequency. Wide-range "L" or pi-network tuners, especially those of the McCoy "ultimate" or "universal" transmatch design can do a fine job of matching less-than-optimized antennas to the receiver, especially since most communications re-

ceivers have little or no provision for precisely resonating the antenna circuits and receiver input. A great deal of signal loss can result, even with antennas worked close to resonance due to the lack of any method of input circuit matching. The antenna tuner serves to clean up these deficiencies.

Since there is no transmitter or s.w.r. bridge to indicate proper antenna coupler tuning, this is normally done by ear or S-meter, adjusting the tuner's tuning capacitors and inductor on a steady signal or even on background noise until the received signal is peaked. It's possible to use the ANB to set the tuner; one manufacturer, Palomar Engineers, markets an antenna tuner that incorporates a built-in ANB for tuneup *without* radiating a signal. (The unit is a heavy-duty, 2 kw-rated transmitting type that would be far heavier than required for receiving use, however.)

Antenna Of The Month

This month's antenna feature is the Datong AD-170 active antenna, a British import marketed in the United States by Gilfer Shortwave. Because of its compact size and portability, it's of special interest to the traveler and the apartment or condominium dweller who wishes to benefit from good antenna performance over a wide range —60 kHz to 70 MHz in the case of the AD-170.

The Datong antenna is a 3-meter long indoor amplified dipole that has its own matching circuit or direct connection to the receiver; its frequency response is substantially flat to minimize intermodulation effects. See insert photo for a description of this unusual antenna.

Questions And Answers

Some questions about antenna design and installation recur with every generation of hams. One of the most persistent questions is the following:

"I live in an apartment building owned by a man who will not allow me to install an antenna on the roof. Do you have any suggestions for an indoor antenna and can I expect it to work?"

The whole subject of indoor and "half-outdoor" antennas is a difficult and broad one for which there is no simple answer. Most indoor antennas work poorly, especially on transmit, for a number of reasons: they are shielded by the building's frame, they are affected by close proximity to other (especially metal) objects, they pump r.f. into just about everything in the apartment, and directivity can't be controlled. If the whole antenna must be installed indoors, it may take some ingenuity and experimentation to get it working properly.

The simplest h.f. indoor antenna is an end-fed, long-as-possible randomwire strung around the house and fed, through a transmatch, against ground. Performance is especially difficult to predict due to the nonresonant antenna length and the fact that the effectiveness of the ground system plays an important part in determining how well the antenna works. In many cases, a *real* r.f. ground can't be found in an apartment; counterpoise or artificial ground systems strung around baseboards or tucked under rugs must be installed on a cut-and-try basis for proper antenna loading and matching and to minimize problems with hot r.f. on hamshack equipment.

For indoor use, I am partial to dipole-type antennas installed in the attic or suspended from the ceiling (if possible) and bent around in a symmetrical fashion to form a sort of square loop; the ends can also be bent down in the vertical plane. This type of antenna can be fed with coaxial cable which will minimize grounding and hot-r.f. problems. A dipole installed half-indoors and half-outdoors (center at a windowsill) is one arrangement I've had some luck with.

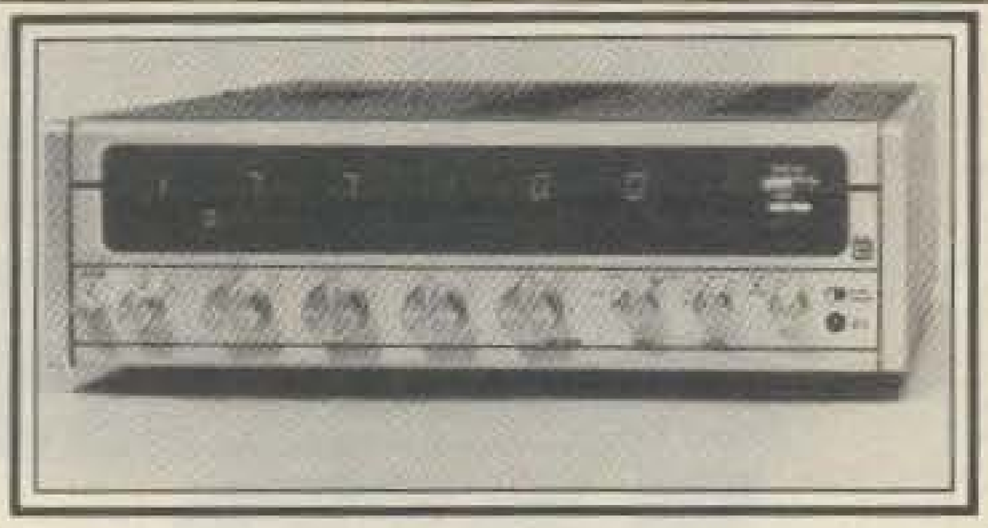
Before completely giving up on an outdoor installation, you may find you have an "out" by erecting a nearly-invisible antenna on the premises. This is done by using very small diameter antenna wire, such as No. 28 or No. 30 plain enameled, button insulators, nylon fishing line, and so on, hopefully with no one the wiser.

A number of possibilities exist for the ingenious cliff-dweller. It may even be possible to construct a regular coax-fed Vee-shaped dipole with the apex at a window. You may be able to install a vertical dipole if you live in a mid-height apartment of a high-rise, or a base fed vertical if you're stuck in a lower floor apartment. Another possibility is to adapt a standard mobile antenna mount, coil and whip for windowsill angle mounting; Barker and Williamson sell a special loaded antenna designed for semivertical installation in an apartment window.

I chose to highlight this particular problem in this month's column since it's one that is common to amateurs and shortwave listeners alike. In next month's column, which continues our discussion of receiving antennas, we will focus on compact commercial designs that offer additional alternatives to space-restricted individuals.

Reader Feedback

Nothing makes an author feel quite so good as getting a stack of letters asking for more information on an intriguing subject, complimenting him for presenting material in a fashion



DR22C general coverage receiver is shown above. Covering 50 kHz to 29.7 MHz, the unit covers all the popular long, medium and short-wave bands in an attractively styled desktop design. Some features include PLL digital synthesis tuning, no mechanical tuning dial error or backlash, high level r.f. front end for excellent intermodulation rejection, crystal and ceramic i.f. filters, selectable 4/8 kHz bandwidth, 5 kHz audio heterodyne notch filter, typical 1 microvolt sensitivity or better on most bands, and special a.m. envelope detector for better audio recovery of a.m. broadcast and SW stations. Set receives a.m., u.s.b., l.s.b. and c.w. modes. (Photo courtesy McKay Dymek)

that allowed a reader to solve a particularly knotty problem he was having, or simply telling him that he enjoyed a certain piece. Helpful reader mail includes letters that point out an error or omission in an article, suggest future material to be covered, and contribute photos or ideas for development in future columns.

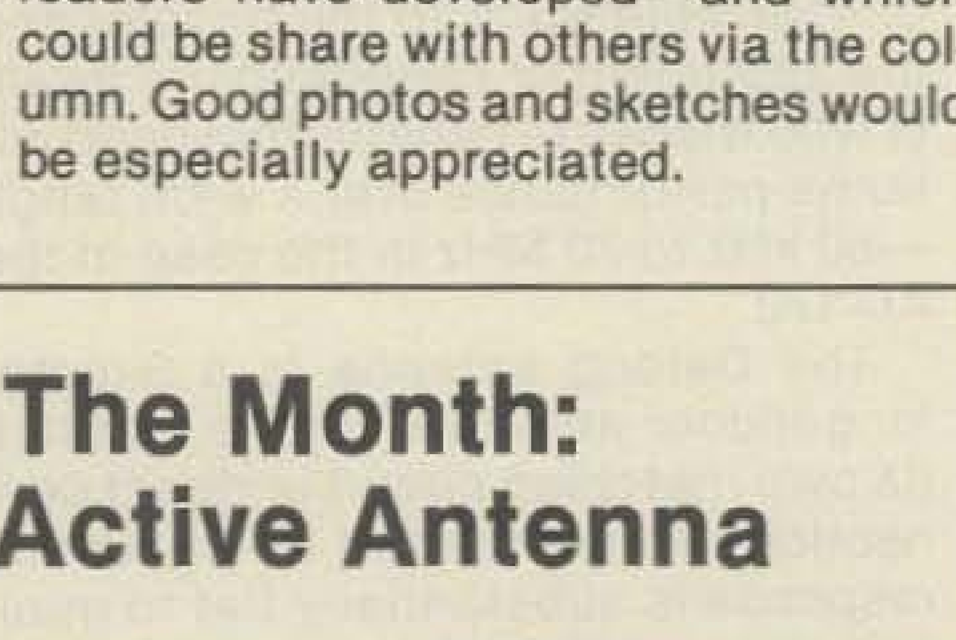
On the other side of the coin, reader mail also includes correspondence from people who simply want to criticize, those who demand customized design information featuring "complete details" on an antenna system for their needs, as well as those who never thing to include a stamped, self-addressed envelope as a courtesy. We receive both types of correspondence.

Trying to keep up with and answer mail is a moral obligation on the part of the author and the magazine, in my opinion. As much as the *CQ* staff and I would like to help solve readers' antenna problems, it's frequently impossible for reasons of cost, time, and what might be called "engineering feasibility"; it's not usually practical to design a complete antenna system to meet one's individual station needs. Few authors have the time and facilities available to take on such chores; I know that I don't!

Nevertheless, I'll try to reply to all *reasonable* inquiries that are accompanied by a courtesy SASE. I'd especially like to receive details of unusual but successful antenna systems that readers have developed—and which could be share with others via the column. Good photos and sketches would be especially appreciated.

Antenna Of The Month: Datong AD-170 Active Antenna

Another active (electronic) antenna system of special interest to the traveler and to the apartment dweller is the Datong AD-170, a British import distributed by Gilfer Shortwave. An extremely compact and portable system, the indoor system shown has wideband coverage from 60 kHz to 70 MHz; since no tuning or other adjustments are required to cover the full frequency range, it is especially suitable for attic or ceiling mounting.



The overall antenna length is but 3 meters; its dipole configuration allows choice of horizontal or vertical mounting with no ground plane or earth connection required. The system features switchable 12 or 24 dB gain and 50-ohm output for matching to most receivers' input circuitry without the use of an antenna tuner or coupler. A flat frequency response is said by the manufacturer to minimize intermodulation effects in strong-signal areas.

According to the manufacturer, the heart of the system is the "electronic balun" at the center of the dipole, an amplifier using field effect and bipolar transistor circuitry. Power to the unit is supplied by the interface unit (12 v.d.c. converter supplied).

A short (4-meter) length of coax is supplied, and it may be extended in length as required. PL-259, RCA phono, or spade lug antenna terminals are available.

Mfr: Datong Electronics Ltd.
Spence Mills, Mill Lane
Bramley, Leeds LS13, 3HE
England

U.S. Distr. Gilfer Shortwave
Box 239
Park Ridge, NJ 07656

Wrap-Up

In this two-part series we have drawn parallels between receiving and transmitting antenna requirements and characteristics. We've discussed several basic antenna forms, including the randomwire, dipole and vertical. And we've also mentioned some practical ways to tune up that newly erected receiving skyhook.

Next month, we will cover more sophisticated antennas such as loops and specialized antennas for the space restricted listener and the traveler. We will also cover a number of important and useful receiver-enhancing accessories. See you then.

73, Karl, W8FX

Bibliography

Listed below are selected sources that amplify and support the antenna subjects covered in this month's column. They're all in addition to the basic antenna and radio handbooks—good sources for receiving as well as transmitting antenna design information. Consult your local library for the older issues.

1. Althouse, Jack, K6NY. "Antenna Tuning With a Noise Bridge," *Ham Radio Horizons*, November 1978.
2. Ashe, Jim, W2DXH. "Simplest Antenna Bridge—Get the Most Out of Your SWL Antenna System," *Popular Electronics*, April 1969.
3. Clark, Benjamin, WB4OBZ. "The Art of Dipping," *QST*, January 1974.
4. *Communications World*, an annual shortwave DX'ers guide published by Davis Publications, Inc., New York. 1979 edition.
5. Drumeller, Carl C., W5JJ. "Antenna Tuner for SWL's," *Popular Electronics*, January 1973.
6. Fisher, James M., W3KNG. "Wire All-Band Antennas," *CQ Magazine*, November 1978.
7. Goldman, Morrie S., "A Short Course in Understanding Shortwave Receivers," *Elementary Electronics*, November-December 1979.
8. Jackson, Albert H., VE3QQ. "A Simple Open-Wire Protector," *CQ Magazine*, April 1980.
9. McCoy, Lewis G., W1ICP. "A Windowsill Semivertical and Other Antenna Ideas for Apartment Dwellers," *QST*, June 1967.
10. McMullen, Thomas, W1SL. "Use Your Dipper," *Ham Radio Horizons*, August 1979.
11. Noll, Ed, W3FQJ. "Using Antenna Tuners," *Elementary Electronics*, November-December 1979.
12. Noll, Edward M. "Your Antenna—Key to World-Wide DX," *Popular Electronics*, November 1959.
13. Orr, William I., W6SAI. Antennas column in *CQ Magazine*, July 1974.
14. Pyle, Howard S., W7OE. "Receivers Need Antenna Tuners Too!", *Radio-TV Experimenter*, October-November 1966.
15. Richardson, Robert M., W4UCH. "A Tribander for the Attic," *73 Magazine*, May 1980.
16. Thurber, Karl T., Jr., W8FX. "All About Traps and Trap Antennas," *Ham Radio Horizons*, August 1979.
17. Thurber. "Enjoy All Five Bands—with this Novice Non-Trap Antenna," *73 Magazine*, July 1978.
18. Thurber. "Lightning and the Ham Shack," *Ham Radio Horizons*, July 1978.
19. Thurber. "Matching Your Way to DX: A Look at the Transmatch," *CQ Magazine*, February 1980.
20. Thurber. "The Antenna: Getting Out the Signal," in the Amateur Radio column, *Popular Electronics*, September 1978.
21. Van Wickle, W6TKA/Ø. "A Procrastinator's Special: A Simple Six-Band Antenna," *73 Magazine*, January 1980.

a monthly feature by
KARL T. THURBER, JR., W8FX

Antennas

DESIGN, CONSTRUCTION, FACT, AND EVEN SOME FICTION

More On Antennas For The Listener

Last month, our columnist W8FX concluded a two-part discussion of receiving antennas. He reviewed common antenna types and their use in specific receiving applications. This month, in response to reader mail, he continues with a discussion of some specialized antennas you're sure to find interesting. Who knows, if the ham bands become frustrating, you may want to take a break for some old-fashioned Dx'ing!

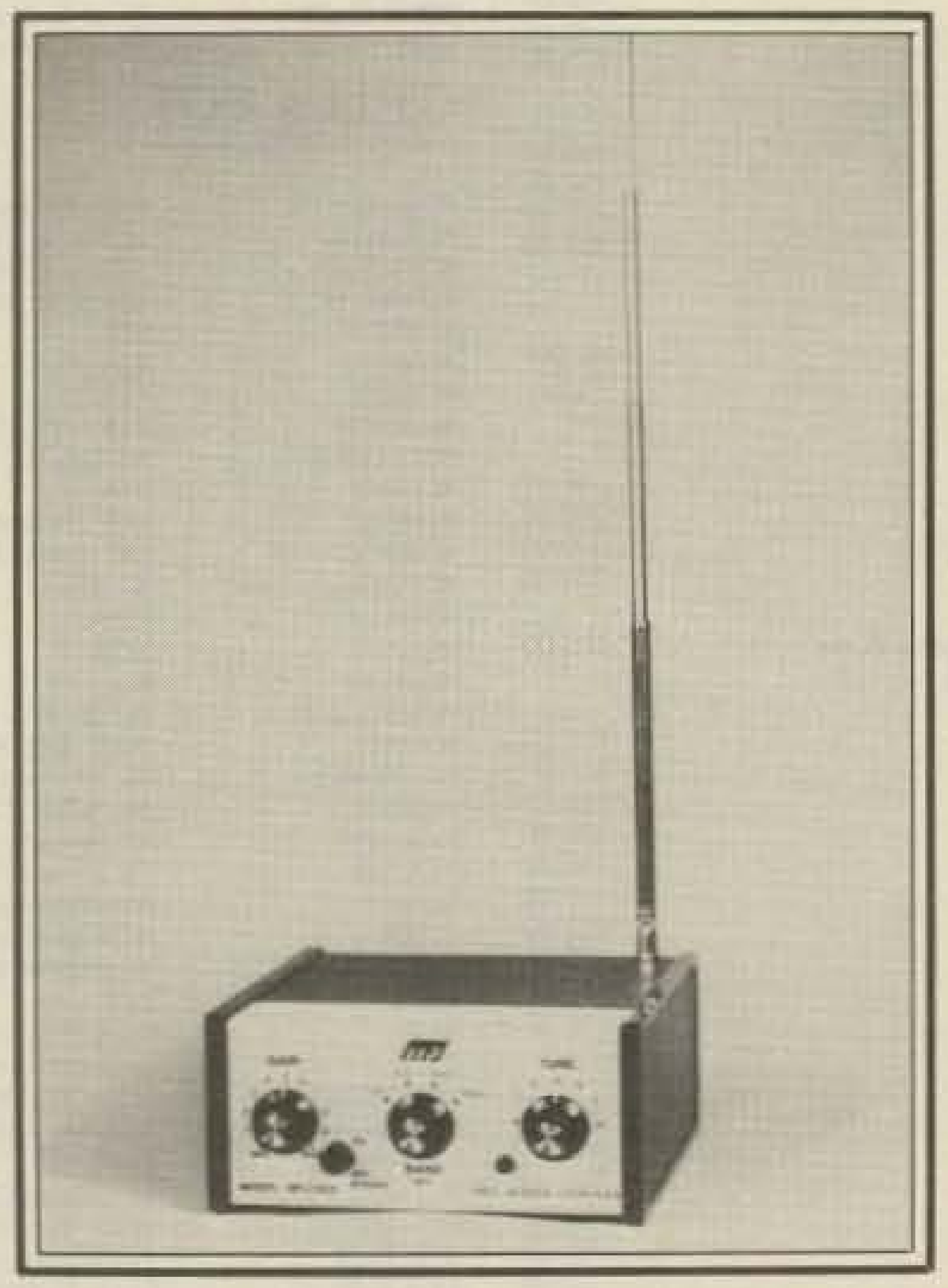
When it comes to receiving antennas, the old adage "simplest is best" usually holds forth. This saying especially applies to the antenna designs we have discussed in previous months: the randomwire, dipole, and vertical. However, in certain situations regular antennas are too noisy for practical use, or they are too long and cumbersome to meet limited space or portability requirements. In this treatment of antennas for the listener, we will discuss receiving loops, highlight some interesting and unique space-saving antennas, and mention some performance-enhancing accessories designed to improve your listening results.

Let's first talk about low-noise receiving loops.

Receiving Loops

Long singlewire antennas, especially at the lower frequencies, develop a good deal of signal but are likely to drive one nuts from the high noise levels that are commonly associated with most urban and suburban locations. Loops, on the other hand, are good antennas for v.l.f. through at least the lower h.f. ranges in that they can be used to null out interference—whether it be from undesired co-channel or adjacent channel stations, or from man-made sources.

Most loops boast a figure-eight reception pattern, somewhat similar to that of the half-wave dipole. The basic loop is a coil or wire whose diameter is small in relation to the wavelength (frequency) to which it is tuned. However, the actual configuration can be in the form of a diamond, octagon, triangle, or other shapes.



Indoor tuned active antenna is designed for desktop use and covers 300 kHz to 30 MHz in five bands. Tuned, adjustable telescopic antenna minimizes intermodulation effects, provides a degree of r.f. selectivity, and reduces detected noise outside the tuned band of interest. Boasting bipolar solid-state circuitry, the unit can also be used as a preselector for an outside antenna. System works off of 110 v.a.c., 9–12 v.d.c., or 9 V battery for portable use. (Photo courtesy MFJ Enterprises)

There are many advantages in using loops, especially in space-restricted situations. They can work well yet be physically small, they can be rotated in both horizontal and vertical planes to take advantage of their directionality, and they can be peaked to a given frequency. Loops that are enclosed in a special, nonmagnetic shield for noise reduction are frequently much quieter than outdoor antennas. The bottom line can be a significant increase in the signal-to-noise ratio—very desirable for DX work. Because they are directional and can be rotated, loops suffer a lot less from swamping and intermodulation effects from strong local stations than their wire counterparts.

Loops are not—at least yet—staples at your local discount radio store. You may have to build one yourself if you want to check out loop antenna characteristics. Few commercial loops are available for the listener market, though Radio West, 3417 Purer Rd., Escondido, CA 92025, has marketed several preamp loops that cover the l.f., m.f., and h.f. ranges; McKay Dymek, P.O. Box 2100, Pomona, CA 91766 sells the model DA5, a preamplified broadcast band (BCB) directional loop, as well as the DA7, a shielded ferrite rod antenna for the longwave and medium-wave bands. Palomar Engineers sells a neat loop/amplifier system for v.l.f. through h.f. that uses several interchangeable plug-in coils.

This month, it's our pleasure to review the Palomar loop (specifications are described in the insert photo).

I had the opportunity to do a "hands-on" check of the compact Palomar unit. Never having worked with receiving loops before, I was pleasantly surprised at the little unit's excellent performance. The loop did all it was advertised to do in reducing man-made noise and nulling out local ground-wave interference, and it produced good signal levels as well.

I was able to check out both the BCB and 160/80 meter loops; it was an interesting experience. On the broadcast band, using the antenna with a Clegg AB-144 up-converter feeding a Kenwood TS-700SP, it was surprising to find that, almost without exception, signals were stronger on the indoor loop than on the outdoor 30-foot randomwire. The elevation and azimuth adjustments allowed co-channel BCB signals to be very nicely nulled out, or desired signals peaked. It was found that in the author's former northwest Florida QTH, where Central American and Caribbean BC stations compete with domestic broadcasters for channel supremacy, it was often possible to receive two separate signals, one U.S. and the other Latin, on the same channel with little or no interference simply by rotating the loop accordingly. Very deep nulls could be obtained on local BC stations by "working" the loop in azimuth

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Many SWLs and amateurs too got their start in electronics by listening for distant stations on the medium-wave or standard broadcast band. The difficulties of digging down for rare, transoceanic DX on the medium waves presents a real challenge, one that's said to equal that of DXCC or WAZ on the ham bands. Some requirements for success include a highly selective receiver for split-frequency operation, a good outside antenna, and possibly a directional loop, as well as a low-noise location. Lots of midnight oil and a good deal of patience help, too. If you want to get your feet wet in BCB DX'ing, the following should keep you busy:

Callsign	Freq. (kHz)	Location	Station power (KW)
XEWA	540	San Luis Potosi, Mexico	150
CMW	600	Holguin, Cuba	150
CMQ	640	Havana, Cuba	50
KORL	650	Honolulu, Hawaii	10
YSS	655	San Salvador, El Salvador	10
—	657	Kangnam, North Korea	1500
—	665	Lisbon, Portugal	135
—	738	Tel Aviv, Israel	1200
JOIB	747	Sapporo, Japan	500
—	765	Dakar, Senegal	400
JOUB	774	Akita, Japan	500
PJB	800	Bonaire, Netherlands Antilles	500
—	834	Belize City, Belize	20
—	846	Rome, Italy	540
XEW	900	Mexico City, Mexico	250
KHVH	990	Honolulu, Hawaii	10
—	1017	Istanbul, Turkey	1200
—	1017	Wolfsheim, W. Germany	600
4VEC	1035	Cap Haitien, Haiti	10
—	1044	Shanghai, Peoples Rep. of China	300
YVOZ	1200	Caracas, Venezuela	10
—	1395	Durres, Albania	500
4QD	1548	Queensland, Australia	50
—	1557	Nice, France	300
XERF	1570	Ciudad Acuna, Mexico	250
—	1593	Langenberg, W. Germany	800

Table I– DX'ing the broadcast band. There are many books available listing all the foreign broadcast stations. Check the CQ Bookshop and elsewhere in this issue.

and elevation so that weak adjacent-channel signals, previously obliterated, could easily be received through the local splatter and overloading. This also allowed reception of some off-channel split frequency stations previously buried in the QRM. The 160/80 meter loop, which actually covers 1600–5000 kHz, worked nicely and was especially effective in minimizing Loran QRM on 160.

If you'd like to try your hand at medium-wave DX'ing, refer to Table I for a listing of some not-so-hard targets for late-night listening. Table II shows some of the major listener organizations you may wish to contact.

Space-Saving Designs

There are a number of interesting commercial antennas available for specialized DX'ing in addition to compact units you can easily build yourself.

Gilfer Shortwave distributes two restricted-space h.f. antennas in their "RAK series," the RAK-1 and RAK-3. Both are designed for outdoor installation. The RAK-1 is a mini-dipole that requires less than 22 feet of horizontal space. It uses a loading coil and folded-back section which also forms a part of the lead-in. The RAK-3 is a double dipole consisting of two separately resonant segments fed by a single coaxial cable. The lengths of the two dipoles and the angular spacing between them are said by the manufacturer to hold the impedance reasonably constant between 50 and 100 ohms, from 3 to 30 MHz.

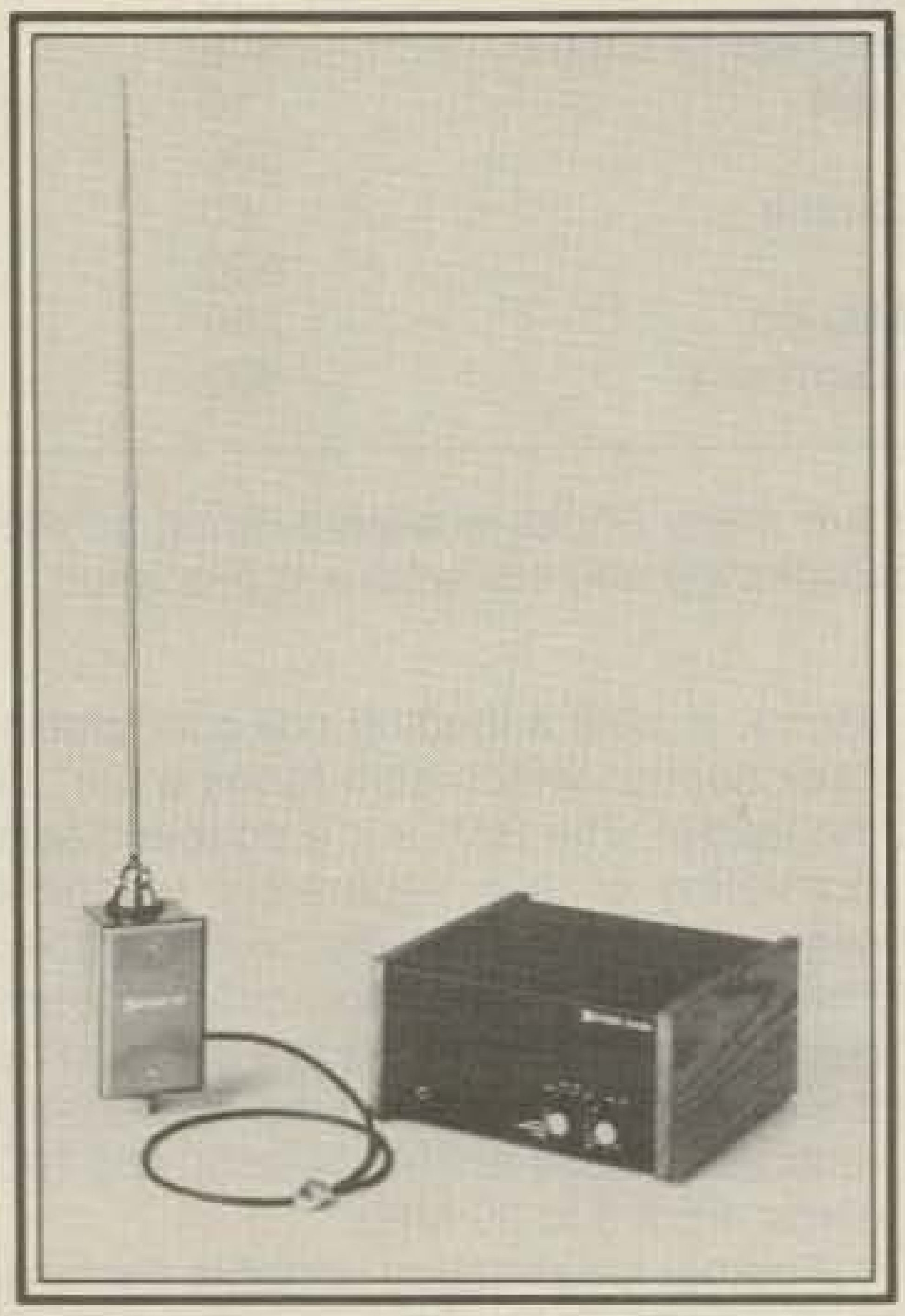
Another small-space portable antenna that reportedly works well is the coiled-spring Slinky dipole, a variable-length, electrically shortened h.f. antenna that is available in both amateur and s.w.l. versions. The s.w.l. model can be used in any of two modes: tuned or untuned. To be used in the *untuned* mode, it is simply stretched out in any direction to cover as great an area as possible of your attic, yard, motel room, apartment, or whatever. The antenna is connected to the receiver through a length of coaxial cable; it's usable from about 500 kHz to 54 MHz, or from 600 meters to 6 meters. Used in the *tuned* mode for optimum performance on a particular band, the antenna is simply set to the length specified in the instructions. When in use, the coiled arms

Contact these organizations for information on their programs and publications. In most cases, a large s.a.s.e. or a nominal fee is requested to cover the cost of mailing a sample bulletin and other literature:

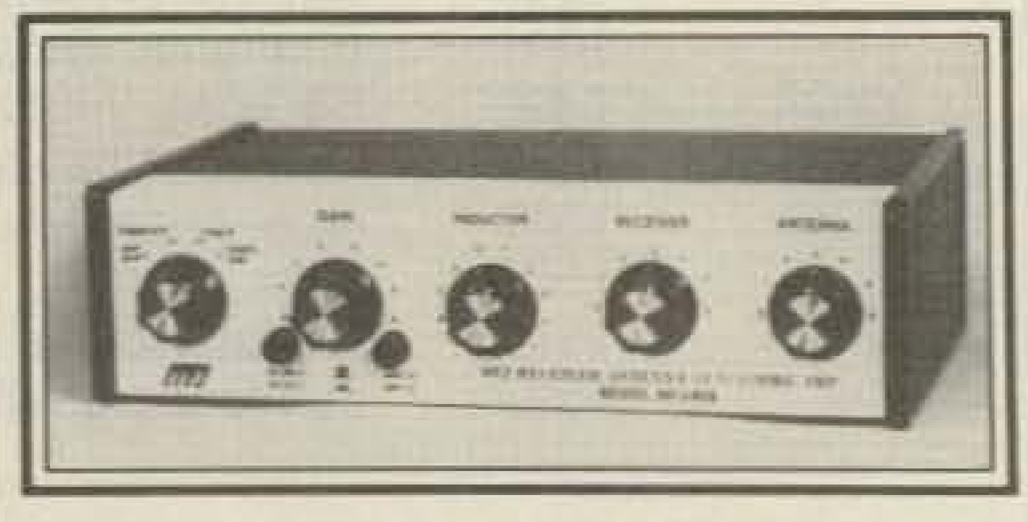
- National Radio Club, Box 118, Poquonock, CT 06064. Publishes the *DX News* 30 times a year. Also distributes an extensive listing of technical reprints. Specializes in broadcast band monitoring.
- International Radio Clubs of America, Box 21462, Seattle, WA 98111. Publishes the *DX Monitor* 34 times a year, as well as several specialized publications. Devoted primarily to DX'ing on the AM broadcast band.
- Longwave Club of America, P.O. Box 33188, Granada Hills, CA 93144. Publishes *The Low Down* on a monthly basis. Longwave only.
- Newark News Radio Club, P.O. Box 539, Newark, NJ 07101. Publishes the *NNRC Bulletin*. Mediumwave/shortwave.
- Speedx, P.O. Box E, Elsinore, CA 92330. Publishes *Speedx* each month. Focus is on shortwave broadcast and utility station DX'ing.
- Miami Valley DX Association, 4666 Larkhill Lane, Columbus, OH 43229. Issues the *DX World* monthly. A general interest club.
- American Shortwave Listener's Club, 16182 Ballard Lane, Huntington Beach, CA 92649. General interest, including utility DX'ing.

In addition to these, the umbrella organization of domestic listeners' clubs is the Association of North America Radio Clubs (ANARC), 557 North Madison Avenue, Pasadena, CA 91101. For an s.a.s.e. ANARC will send you information and listings of all its accredited member clubs.

Table II– Major listener club and organization sampler.



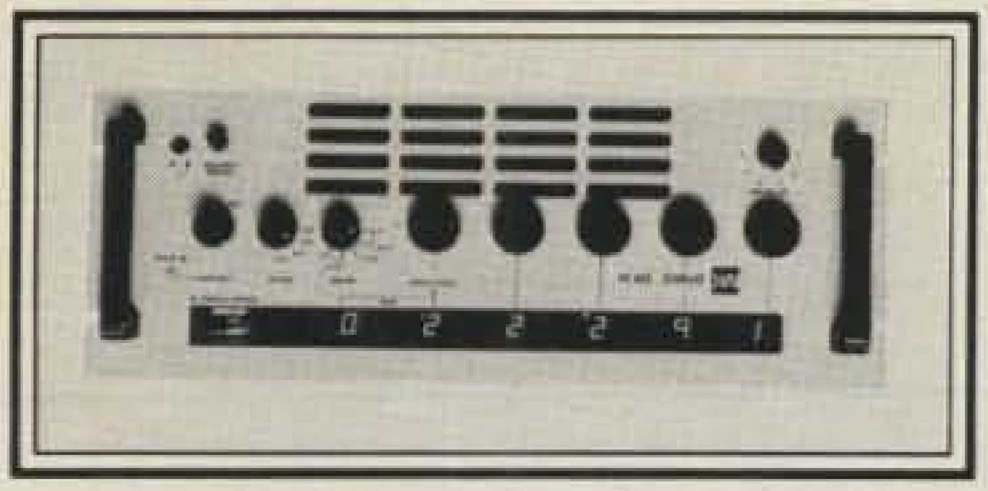
Four-and-one-half-foot whip at the heart of the McKay Dymek DA-100 is directly coupled to a base-mounted preamplifier for high performance over the range of 50 kHz to 30 MHz. Fed through 50-ohm coaxial cable from a control module located at the operating position, the control box includes a combination attenuator/impedance matching switch used to match receiver impedances from 50 to 500 ohms or to introduce up to 20 dB of signal attenuation when required. The antenna can be installed outdoors in either a horizontal or vertical configuration; the weatherproof housing can be mounted atop a TV mast or placed on a flat surface, such as a balcony or window ledge. (Photo courtesy McKay Dymek)



MFJ antenna tuner/preamp allows matching of the antenna to the receiver and up to 20 dB preamplification for weak-signal work. Usable over the range 1.6 to 30 MHz and capable of handling two antennas and two receivers, the operator can select tuner-only, tuner with preamp, tuner with 20 dB preamp, or bypass functions. Unit includes an adjustable gain control and has both coax and phono jacks. (Photo courtesy MFJ Enterprises)

of the dipole (which contain a total of 335 feet of conductor) act like distributed inductances to enable the Slinky's effective electrical length to be as much as five times the physical length. The antenna is made by Teletron Data Corp., Kings Park, NY 11754.

The Partridge Joystick is a British import first introduced in 1960 by G3CED. Separate versions are available for high-power amateur and low-power or SWL use. The Joystick system consists of three main elements: the eight-foot-long metal-tubing VFA (variable frequency antenna) radiator with built-in center loading coil, the singlewire transmission line, and the antenna tuning unit (ATU). The Joystick is an omni-directional antenna when mounted vertically; it can also be mounted horizontally or at the odd angles sometimes required for difficult apart-



For the amateur whose attention has focused on ham-band gear in recent years, there is a good deal of sophisticated communications gear that has been introduced to fill military, industrial, and maritime needs. A good example of such equipment is this McKay Dymek DR 44, a "professional" receiver covering 50 kHz to 29.7 MHz continuously. Set features PLL digital synthesis, special a.m. envelope detector, crystal and mechanical i.f. filters, high level r.f. front end, and independent selection of reception mode and i.f. filter. The unit also boasts a double balanced diode ring mixer, which is said to provide freedom from intermodulation interference and overload in strong-signal areas while eliminating the need for a manually adjusted antenna preselector in many installations. Note the unusual five-knob "dial-in" frequency selection scheme. (Photo courtesy McKay Dymek)

Antenna of the Month: Palomar Engineers Loop Antenna

Palomar Engineers amplified loop antenna is of interest to serious l.w., m.w., and s.w. hobbyists who find that noise and interference are wiping out their listening enjoyment. A well-known fact that loops pick up less noise than conventional antennas, the difference is especially noticeable on the lower frequency ranges where vertical antennas are often used for DX work. On transmit the vertical usually gets out well, but on receive it is very susceptible to noise pickup. Thus, in a very noisy location the loop is apt to be far superior for reception. In addition, the loop can be used to null out specific interfering stations, especially those received on groundwave from local sources.

There are two components to the Palomar system. (1) The loop amplifier, built into a small die-cast aluminum case that has as its heart a 20 dB gain FET amplifier working over the range 10–5000 kHz, and powered by a 9 v.d.c. battery; and (2) the loop antenna itself, measuring 8" × 6" × 1½", a balanced Litz winding with a Faraday shield over a ferrite rod. There are actually provisions for five or more antennas, covering the ranges 10–40 kHz, 40–150 kHz, 150–550 kHz, 550–1600 kHz, and 1600–5000 kHz; the loops are variable over an azimuth scale of 0–360 degrees and an elevation scale of ±90 degrees, both in 5-degree increments. The loop amplifier serves as the mounting base for the antenna.

After being installed on or near your set and connected to it through a short length of coax, the unit is operated by peaking the loop response using the loop tuning control. If there is local interference, the loop is rotated for minimum signal and the loop then tilted as necessary to produce the best null. Photo courtesy Palomar Engineers.

ment window or balcony installations. For receiving, many DX'ers have reported good results indoors when the antenna is simply leaned against an exterior wall—just be sure to keep the antenna away from large objects. Essentially a short, loaded singlewire system, the Joystick depends to a large extent on the quality of its ground system, especially when used to transmit. The antenna, which covers 500 kHz to 30 MHz continuously, is distributed directly by the manufacturer, Partridge Electronics, Ltd., Broadstairs, Kent, CT10 1LD, England.

McKay Dymek manufactures the DA100, a small-space unit designed for outdoor use, which is directly coupled to a preamplifier located indoors near the receiver. The antenna (whose auto-style whip is only 4½ feet tall) is designed to provide good performance over the range 50 kHz to 30 MHz. It is fed with 50-ohm coaxial cable routed to a control module at the receiving position. Antenna polarization can be set horizontally or vertically; the watertight housing can be mounted on a flat surface, such as a window ledge or balcony, or installed atop a TV mast. The unit will match receiver input impedances over the range 50 to 500 ohms. The control box can introduce up to 20 dB of signal attenuation when required to reduce intermodulation interference in r.f.-dense urban areas.

For the traveler, the Datong AD-170 and MFJ Model 1020 indoor active antennas are attractive. We described the AD-170 dipole last time as our "antenna of the month" feature, so we won't go into it again. The MFJ device is an interesting unit designed for easy portability and desktop use. It covers the major l.w., m.w., and s.w. bands from 300 kHz to 30 MHz in five ranges. The unit has its own telescopic antenna, but the bipolar solid state preamp circuit can perform double duty as a preselector for an outside antenna.

For the builder, there are a number of compact receiving systems described in the popular literature. Perhaps one of the best of these is the intriguing 12-inch-long homebrew active antenna described by Douglas Blakeslee, N1RM, in the June 1979 issue of *Ham Radio Horizons*. N1RM's broadband antenna covers 160 through 10 meters, including all the shortwave space between.

(To Be Continued)

a monthly feature by
KARL T. THURBER, JR., W8FX

Antennas

DESIGN, CONSTRUCTION, FACT, AND EVEN SOME FICTION

Improved Receiver Performance

Most current solid-state communications receivers are a far cry from those offered the listener of 10, 15, or 20 years ago. Virtually gone are annoying tube-set characteristics such as drift, microphonics, barn-wide selectivity, sensitivity drop-off, and images. The use of solid-state circuitry has enabled most of these problems to be conquered one way or another, with the result that even lower-priced portables are stable enough, for example, to be used to receive 10-meter s.s.b. signals and sensitive enough to monitor the 13-meter s.w. band.

Nevertheless, after a short period of operation, you will almost certainly find some small drawbacks in your set that you'll want to compensate for, or you'll seek to increase your receiver's flexibility by adding an antenna coupler, outboard active audio filter, an i.f. converter, or other performance-boosting device. I assume that your radio is basically a *good* one; while some deficiencies can be rectified by means of add-on accessories, others require tearing into the set's insides to the extent that it's not practical to correct them. Basic flaws such as serious mechanical or electrical instability, inadequate bandspread, lack of a beat-frequency-oscillator (BFO), and the like may make adding expensive accessories a marginal proposition.

A particularly useful accessory is the receiving antenna tuner. Not really different from a transmitting tuner except for lighter-duty components, the device is particularly handy to let you match your antenna to your receiver for maximum signal development and transfer. The tuner is a near-must for really effective use of randomwire or tuned-feeder antennas, or for resonating very short antennas on the lower bands. Most any transmitting tuner design can be adapted for receiving use. MFJ makes an inexpensive 1.6 to 30 MHz coupler that includes an optional 20 dB preamp/attenuator. Several low-cost MFJ units can be used for receiving, or you can build your own from junkbox parts for next to nothing.

MFJ-1040 receiver preselector is an excellent accessory for enhancing performance of low- to medium-priced communications receivers, especially portables. Low-noise MOSFET unit boasts up to 20 dB gain over the range 1.8 to 54 MHz. Circuit improves weak signal reception, helps reject out-of-band signals, and reduces image response. The lightweight unit can handle two antennas and two receivers, includes an r.f attenuator, and can be used with transceivers with automatic bypass up to 350 watts input. (Photo courtesy MFJ Enterprises)

Adding a low-noise preamp between the receiver and antenna can do wonders to improve reception, especially with lower-priced, older sets that may lack pep on the higher ranges. Several commercial transceiver/receiver preamps are available from manufacturers such as Ameco, MFJ, and Palomar Engineers. Typically, these units cover about 1.8 to 55 MHz in several bands. They can materially improve weak signal reception, help to reject strong out-of-band signals, and cut down on image response. Some of them are also "bi-linear." That is, they include an r.f. sensing device to allow use with transceivers as well—the preamp is bypassed when transmitting. Some include an attenuator to help reduce intermodulation from strong local signals that might otherwise mar reception of weak ones.

If you want to extend downward the frequency range of your existing receiver, you may want to construct or purchase a v.l.f./l.f. converter. This is a device that up-converts the low, say 10 kHz to 500 kHz band, to a range or ranges that can be detected on an ordinary communications receiver and then processed like other signals. Probably the best-known such converter is made by Palomar Engineers (though there are others on the market); the unit uses a crystal-controlled mixer that up-converts the low-band signals to 3510–4000 kHz. This process allows the receiver's basic specifications such as selectivity, bandspread, reception modes, etc., to be harnessed when receiving low-band signals.

If your problem is that you don't even *own* a communications receiver, an h.f. up-converter may be what you need to explore the popular m.w. and s.w. bands. Clegg made an interesting unit, the AB-144 Allbander, which converts your present 2-meter multimode transceiver (such as the Yaesu FT-221R, KLM 2700, Kenwood TS-700SP, etc.) into a continuous coverage receiver that spans the spectrum from 100 kHz to 30 MHz in eight tuning ranges. These bands are heterodyned by the unit to the 144–148 MHz range. The rationale behind the device is that to many hams who are primarily ham-band-only users, the purchase of an expensive, high-quality, all-wave communications receiver is of perhaps marginal value. I own one of the Clegg up-converters and use it nearly every day with my TS-700SP for general coverage monitoring. It really works!

Other devices such as active audio filters and narrow-response i.f. strip filters can go a long way to make listening and DXing more enjoyable. But then, this is supposed to be an *antenna* column.

Questions and Their Answers

Several months ago we ran a two-column review of h.f. vertical antennas. We didn't say much about the protection of passersby—particularly children—from the possibly dangerous effects of coming into contact with a ground-mounted antenna. The question arises, what are the safety hazards associated with someone inadvertently touching your antenna while you're transmitting?

It goes almost without saying that any antenna (and feedline) should be installed

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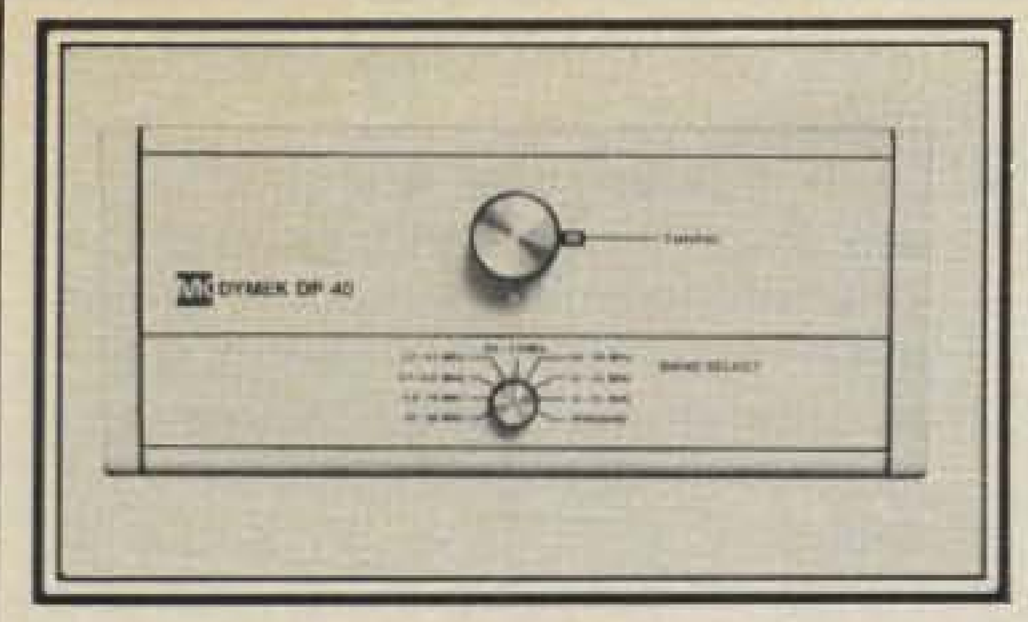


R.f. preselector shown here is non-amplified. *Its purpose is to act passively to shape the input selectivity curve of the receiving system to eliminate undesirable signals. Its nine band-select positions provide a five-element lowpass filter for 0 to 0.15 MHz, dual-track tuned circuits for 0.15 to 30 MHz, and a wideband bypass position to remove the preselector from the antenna circuit when not needed. There is some insertion loss with such a unit, which may run as high as 7.5 dB on some ranges, but this may be offset by the advantages of elimination of cross-modulation interference and receiver desensitization when working near high-powered transmitters. (Photo courtesy McKay Dymek)*

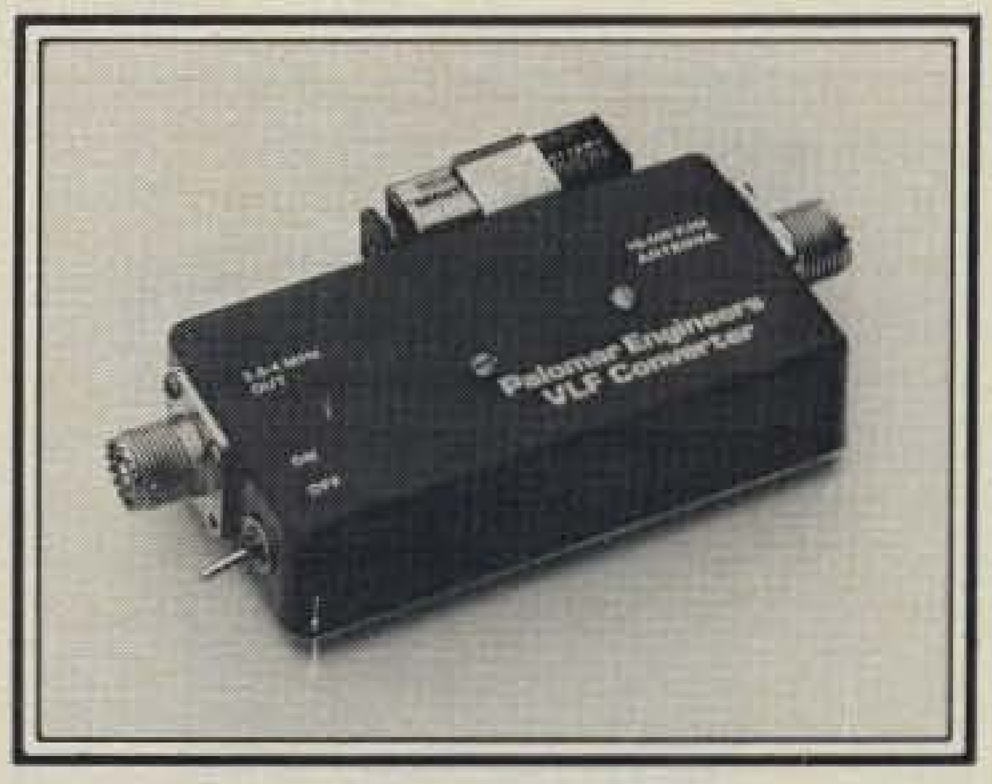
so as to preclude or at least minimize the possibility of physical contact. The two main concerns relate to **(1)** r.f. burns to one's flesh from touching the antenna while transmitting, and **(2)** electrical shock from the antenna caused by its being above a.c. or d.c. ground potential.

While it's a rare case that r.f. energy would be present on an antenna to such a degree that contact would be fatal (even when running a full gallon), a very serious, painful, and penetrating flesh burn can occur. In some cases the flesh can actually be cooked. This would be an extremely unfortunate incident to have occur in your backyard, especially when it would likely involve small children playing in the vicinity of the antenna. It doesn't take much power to do a job on one's hand. In my Novice days, I received some nasty pin-prick r.f. burns fooling around with the tank and antenna circuitry of my 25-watt 40-meter c.w. rig.

An even more serious problem is the possibility of d.c. or a.c. voltages being present on the antenna. Given sufficiently high voltage and lowered skin or body resistance, with the potential for lethal currents to flow through one's body, the antenna can easily kill. Tube-type pi-network rigs that use a d.c. blocking capacitor to connect the tank circuit with the final amplifier tube's plate can cause full transmitter h.v. to be placed on the antenna if the capacitor fails. This creates the potential for electrocution of anyone coming in contact with the antenna. (The possibility can be reduced by connecting an r.f. choke between the r.f. output terminal "hot" lead and ground to short the d.c. to ground and blow the transmitter's power supply fuse, should capacitor failure occur.)

A second "hot antenna" hazard occurs if the antenna is not at a.c. ground potential. This is a rare occurrence in a well-designed amateur station, since care is usually taken to ensure that the equipment cases, chassis, accessories, coaxial transmission lines, etc., are all well grounded. However, in some temporary lashups, such as might occur under vacation or portable conditions, the same care might *not* be taken. Also, many tube-type s.w.l. receivers of the transformerless kind (of which there are still many around today) can put the antenna system at a potential of 120 volts (the power-line voltage) above ground under certain conditions. These could include forcibly inserting a polarized plug the wrong way, failure of a bypass capacitor in the receiver, misconnection of the antenna ground lead at the set, etc. I'm leary of using this kind of receiver with *any* kind of external antenna or ground due to the shock hazard—one that's present whether the set is turned on or not.

So, if you plan to install a ground-mounted vertical, consider how you're going to protect it. A small fence around the antenna may do the trick, or possibly your completely fenced-in and locked yard would be adequate. Before installing the antenna, it's a good idea to make a routine check of things such as your homeowner's or renter's liability insurance coverage and your rental agreement or lease, as well as local electrical and building codes.



If you might like to try out the radio spectrum below 500 kHz, a special low-band converter is required in most instances, since the typical communications receiver does not cover the range, nor does most amateur equipment. Palomar Engineers VLF converter allows coverage of the range 10–500 kHz by up-conversion for reception on any shortwave receiver (or transceiver) covering 3.5 to 4 MHz; normal 80-meter signals are blocked by the unit during l.f. reception. The converter shown in the photo has a crystal-controlled oscillator for frequency stability and accuracy, low-noise r.f. amplifier, and a double-balanced mixer for freedom from strong local signal interference. (Photo courtesy Palomar Engineers)

Always play it safe when erecting and using your antenna system, whether it be for s.w.l.'ing, amateur, CB, scanning, TV, f.m., or whatever use. Consider the following guidelines, any one of which may save your life:

- Don and use a safety belt when climbing your beam tower.
- Disconnect the feedline from your equipment before working on the antenna.
- Never allow anyone to turn your equipment on while you're working with the antenna and thus highly vulnerable to shock.
- Don't try to install an antenna when you're dog-tired.
- Avoid bodily contact with metal surfaces—especially grounded ones—when working on the antenna.
- Don't place antennas anywhere near power lines and never use a power pole for a support.
- Use a wooden, fiberglass, or plastic ladder for outdoor work if one is available; metal ladders are, of course, good conductors of electricity.
- Don't assume power lines are insulated; most are not.
- Don't work alone. Use the buddy system, preferably with someone who knows first aid for electrical shock.
- Don't erect the antenna on a windy day or if the lawn is wet or muddy; watch for threatening weather.
- Tie off tall masts with rope and secure the free ends to prevent a toppling antenna pole from falling onto power lines.
- Once in position, be liberal with your use of guy wires and base support. This will minimize sway and reduce the possibility of the antenna falling on your own home or that of your neighbor under severe weather conditions.
- Fence off easy-to-climb towers and exposed "hot" vertical antennas to prevent accidents involving neighborhood children. Don't rely on warning signs!
- Wire antennas should be strong enough to withstand winds twice as strong as expected local wind gusts. Use no. 12 or 14 for long spans to minimize the possibility of breakage.
- Use three-wire safety grounded a.c. connectors in your shack whenever possible.
- Bear in mind that lightning surges can enter your station via the a.c. lines as well as transmission lines.
- Protect all outdoor antenna installations against lightning strikes, either by disconnecting and grounding the feedline when not in use, or by using a lightning arrestor specifically designed for the transmission line in use.
- Don't forget the rotator control box: a lightning discharge can enter through its control cables.
- If possible, configure your antenna so that the entire antenna and its supporting structure are at d.c. ground potential.

Fig. 1– Playing it safe with antennas.

DA5 ferrite rod antenna is a directional a.m. loop with frequency and sensitivity controls. The system contains an FET two-stage amplifier; the shielded ferrite rod can be rotated and tilted to null out undesirable signals. The system covers the standard BC band from 540 to 1600 kHz and has an output impedance of 50 ohms. Especially designed for enhanced a.m./m.w. reception in marginal signal areas, the antenna checks in at under seven pounds. A desktop unit, the cabinet is finished in teakwood and a contrasting textured black enamel. (Photo courtesy McKay Dymek)

With open season on antenna construction close at hand, it's a good time to stress safety. The risks are there: electrocution by a power line, falling out of a tree or off of a tower or ladder, or losing your grip on a slippery roof. Minimize the risks by using the buddy system—having a friend, the XYL, or a neighbor over to assist you, if for no other purpose than to hold a ladder, rescue you if you get stuck, or summon aid if you become injured. As is always the case with accident prevention, exercising a healthy measure of common sense goes a long, long way.

Fig. 1 presents some useful guidelines for antenna safety.

Wrap-up

That's it for receiving antennas for now. We gave the whole subject a broad-brush treatment; it's obviously one that's yards wide and miles long, too much to cover adequately in a column or two. But we pointed out many considerations involved in basic antenna selection, described some tuning aids and receiver performance-enhancing accessories, and mentioned some new and compact antennas for urban dwellers, as well as some that get high marks for portability.

Low noise-figure Palomar Engineers preamplifier helps pep up receivers that are poor performers on the higher amateur or shortwave bands; up to 20 dB gain is available over the range 1.8 to 54 MHz, or 160 meters through 6 meters. Designed for use with both receivers and transceivers, the added r.f. selectivity introduced by the unit reduces receiver image response and spurious signal reception as well. (Photo courtesy Palomar Engineers)

In the future, we'll dig deeper to cover indoor antennas, antennas for the traveler, and other specialized receiving and transmitting antennas that are far removed from classic designs.

Until then, 73, Karl, W8FX

Bibliography

Listed below are selected sources that amplify and support the antenna and related subjects discussed in this month's column. They're in addition to the antenna and radio handbooks—also good sources for receiving as well as transmitting design information. (Previous *CQ* Antennas columns, though primarily written for amateur transmitting purposes, contain a wealth of s.w. and m.w. antenna information as well.)

1. Bauer, F.J., Jr., W6FPO. "Compact BCB DX Antennas," *Popular Electronics*, January 1965.
2. Blakeslee, Douglas, N1RM. "A Very Short Receiving Antenna," *Ham Radio Horizons*, June 1979.
3. DeMaw, Doug, W1FB. "Beat the Noise with a Scoop Loop," *QST*, July 1977.
4. Drumeller, Carl, W5JJ. "What About an Active Antenna?" *73 Magazine*, April 1979.
5. Genaille, Richard A., "V.L.F. Loop Antenna," *Electronics World*, January 1963.
6. Haskett, Thomas R., "Broadcast Band DX—Getting Started," *Popular Electronics*, November 1964.
7. Helms, Harry L., "Chasing Foreign DX on the Broadcast Band," *Popular Electronics*, June 1977.
8. Thurber, Karl T., Jr., W8FX. "Ham Shack Accessories: What You Really Need," *Ham Radio Horizons*, December 1979.
9. Thurber, Karl T., Jr., W8FX. "RF Test Equipment," *Modern Electronics*, August 1978.
10. Thurber, Karl T., Jr., W8FX. "Station Design," in three parts, *Ham Radio Horizons*, August, October, and November 1978.
11. Turner, Thomas M., K8VBL. "Four-Band SWL Antenna: Resonant Dipoles, for 60-, 41-, 19- and 13-meter Bands," *Popular Electronics*, November 1968.

If you're about to get "into" the serious aspects of listening—whether it be on longwave, mediumwave, shortwave or higher—there are a number of books and other publications you may want to add to your library. Some of these are:

1. Bennet, Hank, W2PNA. *The Complete Shortwave Listener's Handbook*, 282 pages, 1974, $6.95.
2. Ferrell, O.P. *Confidential Frequency List*. 104 pages, $6.95.
3. Jacobs, George, W3ASK, and Theodore J. Cohen, N4XX. *The Shortwave Propagation Handbook*, $7.50.
4. Orr, William I., W6SAI, and S.D. Cohen, W2LX. *Better Shortwave Reception*. 156 pages, 1976, $4.95.
5. Orr, William R., W6SAI. *Simple Low-Cost Wire Antennas*, 192 pages, 1972, $5.95.
6. Schultz, John, W3EEY. *Shortwave Listener's Handbook*. 146 pages, 1975, $5.00.
7. Turner, Rufus P. *The Antenna Construction Handbook for Ham, CB and SWL*. 237 pages, $6.45.
8. Woodruff, Charles. *Shortwave Listener's Guide*. 144 pages, $5.45.
9. *World DX Guide*. $8.75.
10. *World Radio-TV Handbook*. Published annually by Billboard Publications, about 584 pages, $14.95.

Many of the publications listed above can be obtained from the larger amateur equipment suppliers. Or, they may be obtained from specialized mail-order firms such as Gilfer Shortwave, Box 239, Park Ridge, N.J. 07656, or Ham Radio's Bookstore, Greenville, N.H. 03048. Some are available through *CQ's* own Book Shop. (Prices listed are approximate.)

a monthly feature by
KARL T. THURBER, JR., W8FX

Antennas

DESIGN, CONSTRUCTION, FACT, AND EVEN SOME FICTION

Antennas For The Scanner Buff

Scanner topics on the pages of CQ? Yes, indeed. Many readers follow the action on the public service bands as well as on the amateur frequencies that are interwoven with these bands. Many more amateurs will undoubtedly tune to these interesting portions of the spectrum with the introduction of high performance scanners that rival state-of-the-art ham gear for sophistication. In this issue W8FX begins a two-part look at antennas for scanners. You won't be bored!

In the past few months we've sidetracked slightly to discuss a wider range of antenna topics than one would expect to find in an amateur-radio-oriented magazine. We have talked about antennas for the listener in some detail in recent columns, and we're going to continue for one more month "off the beaten path" with a discussion of scanner antennas. Our discussions are really not out of place, since many of us made our entry into ham radio via short-wave listening, and many more enter today via its 1981 rough equivalent—scanner monitoring.

So, if the "purists" wil excuse another two months of excursion into the hinterlands, we'll dig into the subject. We will talk about "what's up there" in scanner country, discuss basic monitor receivers and scanners, point out specific base station and mobile antenna types, and reflect on the new-breed scanners and the antennas that are required to optimize their performance. We will also mention some special-interest scanner groups and publications catering to this specialized kind of hobbyist.

Scanner Country

Though a ham for some 25 years, I'm nevertheless fascinated by the "thrill" that public service band scanning offers. I find this to be increasingly so today because of the outstanding and surprising capabilities of modern frequency synthesized, microcomputer-controlled, digital-readout scanning monitors that make listening-in almost too much fun to tune out.

Several firms publish public service frequency directories of interest to scanner radio enthusiasts. The Bearcat directory, the cover of which is shown here, has a special format that groups frequency listings of police, fire, ambulance, public utilities, railroads, and other services by "listening areas." This type of listing eliminates the "page hunting" common with state-wide alphabetical lists because it groups all of those services within the listening range together. The directory shown is published in two editions, one covering the Eastern USA and the other the Western USA. (Photo courtesy Electra Bearcat div. of Masco Corp. of Indiana)

In what I've loosely called the public service bands are a number of specialized users. These include business/industrial radio systems; marine and mobile telephone systems; military and governmental communication webs; police, fire, and municipal radio networks; the 462–467 MHz "Citizens Band"(General Mobile Radio Service); paging operations; taxicabs; air-to-ground communications; public weather alerting; and many more. Much use is made of the familiar repeater system in which you will normally hear only the base station; there is also full duplex operation, as well as one- or two-frequency simplex. Direct simplex communication is the rule on some bands such as air-to-ground aviation, on which you will more than likely hear high-flying aircraft rather than base stations, unless you live near a transmitter at an airport or an FAA communications site.

The popular scanner bands include six ranges. Starting at the lower end of the spectrum, they are:

1. 30-50 MHz This range, popularly called the VHF-LO band, is somewhat older than the higher v.h.f. and u.h.f. ranges. The 30–50 MHz band is primarily used when relatively long-range, direct communications is required between base stations and mobiles. State and county police and sheriff's departments are major users of the band for reasons of extended coverage area. Channel spacing is 20 kHz and f.m. is almost universally used. There is a slow migration of users to the VHF-HI and u.h.f. bands due to "skip" interference problems and physical antenna size requirements, among other reasons.

2. 118-136 MHz There's a great deal of excitement in store for the eavesdropper on the aviation band, which sits just atop the commercial 88–108 MHz f.m. allocation. Almost completely a.m., the band is used for air-to-air and air-to-ground communications of aircraft (commercial, private, and military), air traffic controllers, control towers, and others. Only recently has the band been added to multiband scanners, so it's important that one use a scanner having both f.m. and a.m. demodulation capability if satisfactory results are to be had in receiving the 118–136 MHz band.

3. 150-174 MHz The "bread-and-butter" range, 150–174 MHz, is popular in urban and suburban areas especially and includes a wide variety of users. These include police and fire departments, railroads and rail terminals, taxicab fleets, government and military agencies, mobile telephone operations, and many others. Band characteristics are roughly comparable to the amateur 2-meter band. F.m. is normally employed, and channel spacings are typically 15 or 30 kHz.

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4. 450-470 MHz This band is especially popular in urban areas where solid but short-range coverage is desired. Taxicabs, mobile telephone systems, and especially police departments are rapidly expanding here where antenna size makes small hand-held units effective. F.m. is the standard, and channel spacing is 25 kHz.

5. 470-512 MHz Really an extension of the 450–470 MHz band, the "T-Band" is named for the fact that it overlaps a portion of the standard u.h.f. television band, equivalent to channels 14 through 20. The band is used in some large metropolitan areas where one or two u.h.f. TV channels may be dedicated to 2-way communications. Many, if not most, of the newer scanners include T-Band, and if you have TV channels assigned, thus at least partially precluding public service monitoring in this range, you can nevertheless punch in the TV stations' audio carriers into your scanner's memory for TV audio monitoring and possibly some u.h.f. TV DXing; for example, channel 20 audio is on 511.75 MHz. F.m. and 25 kHz spacing are usually employed.

6. 806-870 MHz Seen at present on only a few of the newest scanning monitors, this range is the newest range of interest, particularly with respect to hand-held units. Like the T-band, this segment sits inside the u.h.f. TV range, but at the high end. Long-term growth is expected as the lower ranges fill up in the metropolitan areas.

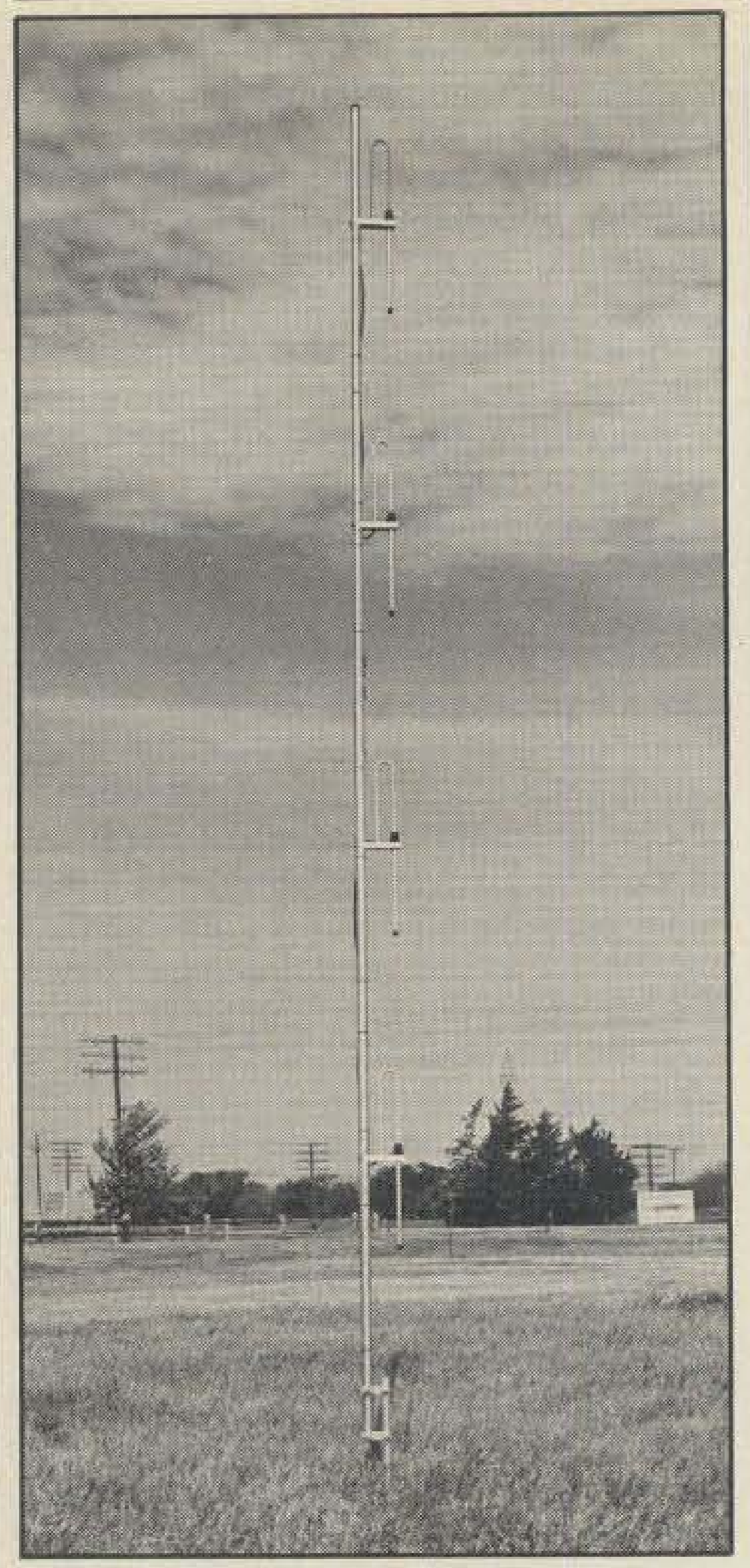
A smart marketing move on the part of the scanner manufacturers was to include the adjacent *ham bands* on many of their models, especially those on the "high end" of their lines. Many of the new Bearcat and Regency scanners include 144–148 MHz and 420–450 MHz coverage (the 2- and ¾-meter bands) where the scanners' f.m. demodulators take to amateur-band signals like duck soup. (Note how the scanners' specs suddenly went from 146–148 MHz to 144–148 MHz coverage once the new repeater subband became effective.) I'm not yet aware of any standard public service scanners that cover the 6- or 1¼-meter bands, but undoubtedly they will appear if the market develops sufficiently.

A point for hams here is that, as police and fire departments have long since learned, conversations are not *private* between units of the communication system. Just about anyone can listen in, and can in practice make any use he desires with what he hears, rightly or wrongly. Thus, it's a good idea to watch what one says when conversing through the local 2-meter "machine." A scanner at your local electronics store or discount house may be tuned in and drawing a crowd of curious passersby!

What about range? I try to associate the key public service ranges with the adjacent ham bands to get a "fix" on the band characteristics that I can expect. In

general, the analogy holds true. Actual range, of course, depends upon a number of factors including antenna type and gain, location, height, and receiver sensitivity, not to mention transmitter power and antenna characteristics on the other end. Typically, with a good monitor setup you should be able to hear base stations and repeaters 30–75 miles away, but mobiles out to only 5–10 miles, depending on the band. Of course, on the 30–50 MHz band, especially toward the low end (adjacent to 10 meters), you may occasionally hear stations hundreds or even thousands of miles away. The low end obviously takes on many of the characteristics of 10, and the high end, those of 6 meters—much to the chagrin of users whose only interest is dependable short-range communications.

Legality is an interesting point that should be considered. *Is scanning legal?* Basically, on the Federal level, it is. There are no restrictions as to what one can listen to; the FCC is mainly concerned with the regulation of transmitting activities, as hams are well aware. "Secrecy of communications" nevertheless is a consideration; the law provides that one hearing information of the type that a scanner can intercept over the air (transmissions not broadcast to the general public) may not disclose the information to a third party. NOAA weather transmissions, naturally, are intended for use by the public, so obviously the secrecy-of-communications rule would not apply in this case, nor would it in the case where you might hear a MAYDAY from a plane or ship, a very real possibility with a



Most public service and related users employ vertical polarization due in no small part to the considerable base-to-mobile use that characterizes the services. Very high-gain, low angle-of-radiation antennas are typical. While the antenna shown here is a Hy-Gain model intended for amateur 2-meter use, it's nevertheless representative of the kind of antenna that's favored by public service users. The J-pole shown is a vertically polarized, broad-band, stacked 4-element model. It can be mounted so as to produce an omnidirectional, unidirectional, or bidirectional radiation pattern to favor the service area intended. Gains up to 9 dB (referenced against an isotropic source) are possible, depending on mounting configuration. (Photo courtesy Hy-Gain Electronics)

marine or aviation band scanner. Pending court decisions on unauthorized pay-TV and direct satellite TV reception could change the rules in the long run, however.

Locally, there can be legal complications. Most states don't place restrictions on *in-home* listening to the public-service bands, but several have statutes which restrict such monitoring while in a motor vehicle. If you plan to install a scanner in your car, truck, or RV, check out the law in your state, county, and municipality—especially with the police, whose job it is to enforce such laws. And if you've got one of the new scanning-type 144 or

220 MHz f.m. transceivers (which look a great deal like public service scanners), carry your amateur license with you.

The Scanner Radio

The scanner is a recent phenomenon. The earliest sets meant for consumer use were police and fire monitor table radios designed specifically for folks such as volunteer firemen. Most of these sets were tunable from 30–50 MHz and/or 150–174 MHz f.m., and some came in 108–136 or 118–136 MHz a.m. versions for aircraft monitoring. These tube-type radios were generally unsatisfactory by present-day standards due to their typically low sensitivity, frequency drift, and difficulty of resetting to a specific frequency.

Later came fixed-tuned monitor receivers, which employed crystal controlled local oscillator circuits to allow reception of desired channels with some degree of precision. Both single- and multiple-channel sets were produced. Some had both fixed (crystal) control and tunable capability in the same set, similar to the early CB radios that allowed crystal-controlled transmit with tunable receive function. Later-generation fixed-tuned sets were of solid-state design and included an r.f. stage, mixer, several i.f. amplifiers, and squelch control all built around a dual-conversion circuit. These receivers, specialized variations of which are produced today, are the forerunners of the modern scanner radio.

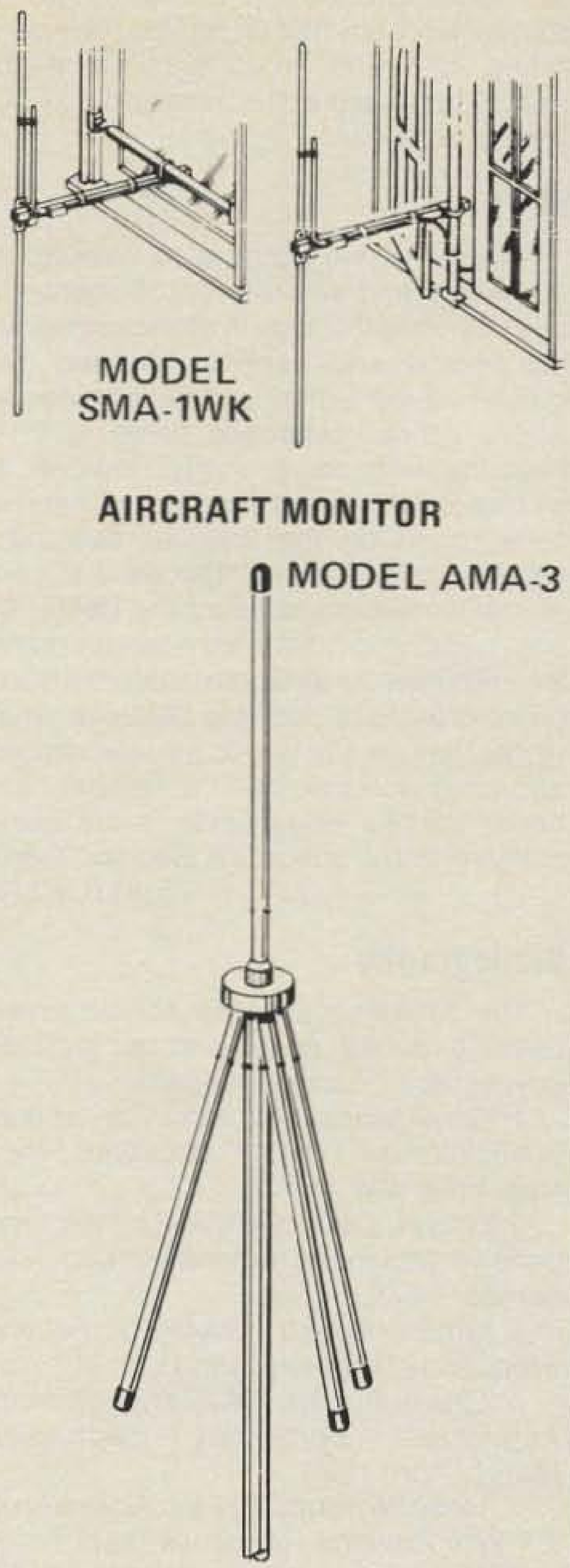
Scanners, since their introduction about 1968, have become almost household appliances, particularly with the advent of the large-scale mass-media advertising campaigns of Bearcat and Regency. In fact, over 7% of U.S. households have one of the more than six million units produced to date. Classic scanners use crystal control of 4 to 20 channels, and can be equipped with the proper crystals to receive fire, police, mobile telephone, marine, amateur, or other services in the unit's range. The scanner rapidly searches through each of the predetermined channels at a given rate, often selectable by the user; nothing is heard until an active channel is located. Then the receiver locks onto this channel and stays with it until the signal goes off the air—or even for a second or two afterwards, to prevent missing transmissions on the same channel when there is a momentary break by having the scanner go back to search mode immediately.

Scanners can be bought for about any price. At the low end of the price range, single-band, crystal-controlled types with 4-channel capacity are common. Such units may be satisfactory for rural-area VHF-LO reception with a limited number of channels in use; using this kind of scanner on the VHF-HI or u.h.f. bands will fast run your crystal costs out of sight unless you wish only to monitor a very few discrete frequencies (thus missing most of the "fun"). A pocket-type scanner with 4-channel capability, particularly if it is of the multi-band type, is usually satisfactory, however.

More useful are 8–16 channel capacity, 2- or 3-band scanners. These units can usually be set up to handle a mixture of channels on all the bands which the set is capable of covering. A crystal-type scanner can be adequate if it has a reasonable number of channels that can be "crystalled up," although at about $5 a crystal, the costs mount steeply as one gets involved in the hobby. Also, crystals are sometimes not interchangeable between different manufacturers' units. Most contemporary scanners operate from house current or 12 v.d.c. and include a separate power cable for either type of power source. Much like current 2-meter gear, most scanners can be slid out of the car and moved indoors for fixed-station use in a twinkling, but have the additional advantage of an internal a.c. supply.

Many 150–174 MHz scanners, although they may not advertise 2-meter amateur coverage, can be retuned to give good performance on the band. Usually, peaking up the r.f. and mixer stages and insertion of the proper crystal is all that is required.

The programmable scanner is rapidly taking over among serious hobbyists,



Representative scanner/monitor antennas are shown by these two Finco designs. Model SMA-1WK is designed for low-, high-, or u.h.f. band use, is vertically polarized, and has special mounting hardware for apartment window mounting. The AMA-3 is designed for specialized v.h.f. aircraft monitoring in the band 118–136 MHz; the drooping ground plane radials give a good match to coaxial cable. (Photo courtesy the Finney Company)

since it has a number of distinct advantages over its crystal-controlled cousins. First, you don't have any crystals to purchase, as the scanner is ready to go on any channel within its operating range as it leaves the factory. Second, the scanner can be set for signals receivable in your area and instantly reprogrammed if you move or if you travel to other areas in your car. And, you can search for *actual* signals that are in use as opposed to signals listed in possibly out-of-date directories, reprogramming the scanner to receive them on the basis of activity. Most of the latest programmables have digital readout of the received frequency, whether in scan, manual, or search modes of operation. Most also have special track-tuning-type r.f. circuitry that allows good performance over an entire frequency band, whereas most "classic" scanners are optimized for reception over a narrow 5–6 MHz range, with sensitivity and overall performance suffering outside this range.

At the risk of touting a particular manufacturer's product, it's easiest to describe "the latest" in scanners by picking a representative "state-of-the-art" unit and running through a few features of interest. The Bearcat 300 is typical of this new kind of scanner. The BC 300, which has over 2100 active frequencies stored in its non-volatile memory, covers all of the bands described earlier, with the exception of the 806–870 MHz u.h.f. band. Its "service search" feature arranges these 2100 stored frequencies into 11 service categories, in accordance with FCC spectrum assignments, for immediate access by interest category. For example, one can depress the "HAM" service-search pushbuttom and all of the popular 2-meter f.m. channels will be scanned. Depressing the "POLICE" button causes appropriate channels in either or all of the VHF-LO, VHF-HI, and u.h.f. bands to be scanned (individual bands can be locked out if desired). Frequencies are programmed into the normal scan operation by keyboard entry; 50 channels, arranged in separately selectable bands of 10, can be scanned at two different rates that are user determined. Sweeps of any segment of any band or an entire band can also be conducted using the search and limit pushbuttons to discover unlisted/unknown frequencies. Many thousands of discrete frequencies can be searched in this manner.

Other interesting features include an automatic counting function that counts the number of transmissions on a channel (to determine the most active frequencies), a built-in quartz digital clock, priority frequency override capability, programmable channel lockout and scan delay, automatic squelch, hold/resume scanning pushbuttons, and direct channel access without stepping through all 50 channels. Sensitivity of the Bearcat unit is rated at 0.4 microvolt for 12 dB SINAD on the VHF-LO and HI bands, and slightly less on u.h.f. Aircraft band (a.m.) sensitivity is rated at 1.0 microvolt for 10 dB SINAD at 60% modulation. As is the case with most present-day scanners, a *single* antenna input jack is used; there are no provisions for separate antenna inputs for each band, though of course a multi-band antenna can (and should) be used for best performance on the seven bands the set covers, or an external combiner or switching device can be used if separate antennas are employed.

Larsen omnidirectional fixed base antenna, shown here, is intended for transmitting applications over the range 136 to 230 MHz, but can easily be used with single-band scanners. The antenna, which provides a stated 3.6 dB gain over standard ¼-wavelength ground plane antennas, features electrical grounding for safety and reduction of static build-up. An adjustment chart is provided to make the three adjustments required to optimize performance on any frequency within the desired range. (Photo courtesy Larsen Electronics, Inc.)

Reader Feedback

In the October and November 1980 issues we featured h.f. vertical antennas of various descriptions, including popular trap and non-trap multi-band designs. One type we did not mention specifically was the Butternut HF 5V-III, a *trapless* vertical antenna that covers 80 through 10 meters automatically. Reader Fred Bonavita, W5QJM, pointed out our lack of coverage of this very unusual antenna. Fred wrote us a lengthy letter pointing out the advantages of the Butternut antenna (he is a well-satisfied owner/user) and the unique feature that it uses no traps. He highlights the fact that the typical trap vertical functions for its whole length only on the lowest band for which it was made. Thus, by his reasoning, if you plunk down $100 for an 80–10 trap vertical, only on 80 meters do you get full use of all that you paid for; on 40 you get a lesser amount; on 20, even less; and so on, all the way down to 10 meters where less than half of what you paid for is working for you. Fred points out that by means of a system of easily tuned, slide-adjusted *loading coils* (not traps) and a practically lossless linear decoupling stub for 15 meters only, the entire 26-foot radiator is active on 80/75, 40, 20, and 10 meters, and a full physical quarter-wavelength resonance on 15 is achieved. This design contributes to greater bandwidth relative to trapped antennas. A low s.w.r. is achieved across all bands (typically 1.5:1 or better), although the operating range is somewhat restricted on 80/75. The interesting 12-pound antenna is shunt-fed with 50-ohm coax at the base and is at DC ground potential.

Wrap-up

This month we became so involved in the why's and wherefores of scanners and scanning that only in the accompanying photos and captions did we get around to the antenna side of things—where we're "supposed to be at." To treat the antennas properly, however, it was necessary to set the stage with some background on the scanner spectrum and the state of the art; this we did. Next month we expect to cover the details of both basic and advanced scanner monitor antennas. As we'll see, there's a good bit of crossfeed possible between what works well on the public service ranges and what works well on the familiar ham bands that lie side-by-side in the same portions of the spectrum. See you then.

73, Karl, W8FX

Bibliography

The following sources should prove useful in boning up on scanner technology, selection, and antennas.

1. *Communications World*, an annual publication of Davis Publications, Inc., New York, 1980.

2. Geiser, David, WA2ANU. "An Inexpensive Multiband Antenna," *QST*, December 1978.

3. Grove, Robert, WA4PYQ. *Federal Frequency Directory*, 1980.

4. Grove, Robert, WA4PYQ. "Scanner Antennas," *Elementary Electronics*, March–April 1980.

5. Hood, William, W2FEZ. *Home-Brew HF/VHF Antenna Handbook*, 1977.

6. McMullen, Thomas, W1SL. "VHF Antenna Matching," *Ham Radio Horizons*, July 1978.

7. Reynolds, Dr. Donald K., K7DBA. "Facts About Proper VHF Vertical Antenna Design," a pamphlet distributed by Advanced Electronics Applications, Inc., P.O. Box 2160, Lynnwood, WA 98036, 1979.

8. "Scanners," in the *Communications Handbook*, an annual publication of the Ziff-Davis Publishing Co., New York, 1979.

9. Von Trott, Albert S., W3UIX/6. "The 'Scrounge'—an Instant 'J' Antenna," *Popular Electronics*, December 1966.

10. Walker, Billy, W5GFE. "Predicting Radio Horizons at VHF," *QST*, June 1978.

11. White, T.E., K3WBH/2. "Antenna Design and Construction Guidelines for the UHF/VHF Amateur Bands," *CQ*, March 1979.

12. White, T.E., K3WBH/2. "Discone VHF Antenna," in the Benchmarks column of *Ham Radio Horizons*, September 1979.

a monthly feature by
KARL T. THURBER, JR., W8FX

Antennas

DESIGN, CONSTRUCTION, FACT, AND EVEN SOME FICTION

Last month CQ columnist W8FX discussed the popular scanner bands, describing "what's up there," and covering basic and advanced v.h.f./u.h.f. monitor radios. This month he has some specific suggestions as to antenna selection and installation.

Last month we branched out from our usual antenna theme to delve into some basics on scanners and the bands they cover. This was done for a purpose: to set the stage for a discussion of specific antennas suitable for the scanner buff. In this month's column we will survey the antennas that may be used for scanner monitoring. We will touch on indoor and base station antennas.

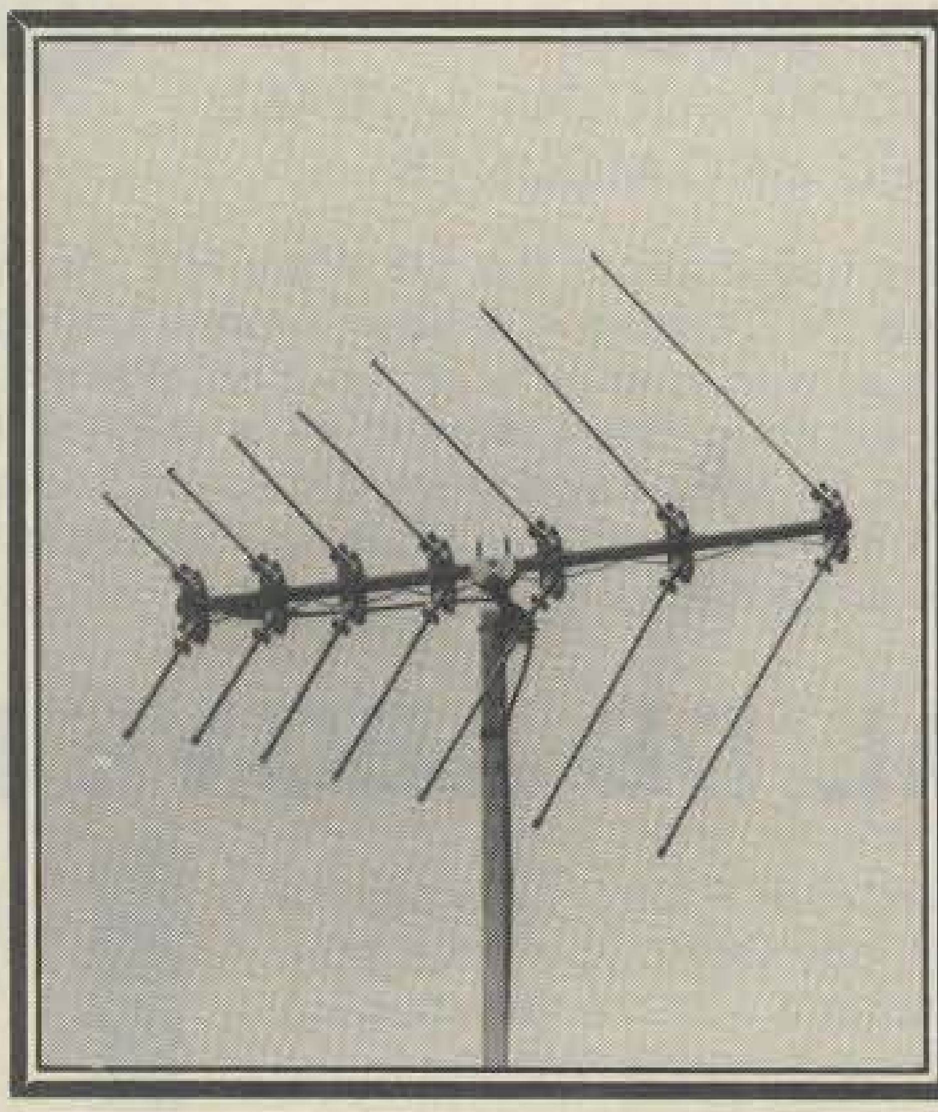
The 21-inch Whip

Aside from your receiver itself, the antenna system is the most important ingredient in an effective monitor setup. The best receiver is practically worthless unless it is given the opportunity to capture the signals that interest you.

Unfortunately, as most scanners come from the factory, they are equipped with a bare-bones telescoping whip that, reception-wise, is about equivalent to the familiar TV "rabbit ears." The short whip will likely be good enough for strong-signal, metropolitan-area listening, but it will leave much to be desired in fringe or near-fringe areas. The limitations of this kind of antenna become readily apparent if reception of distant stations is attempted or if the scanner is located inside a steel-frame building. In such cases, you will likely be able to hear only strong local base stations and repeaters; reception of mobiles will be difficult or very limited.

Low-band (30–50 MHz) results will be especially poor since the typical 21-inch whip is extremely short relative to the usual quarter-wave antenna, and the ground plane formed by the set will be especially ineffective. A 6-foot length of hookup wire will probably do a much better job on the v.h.f.-lo range. It's possible to improve v.h.f.-hi performance by carefully adjusting the whip length to achieve full quarter-wave resonance at the primary frequency of interest, however.

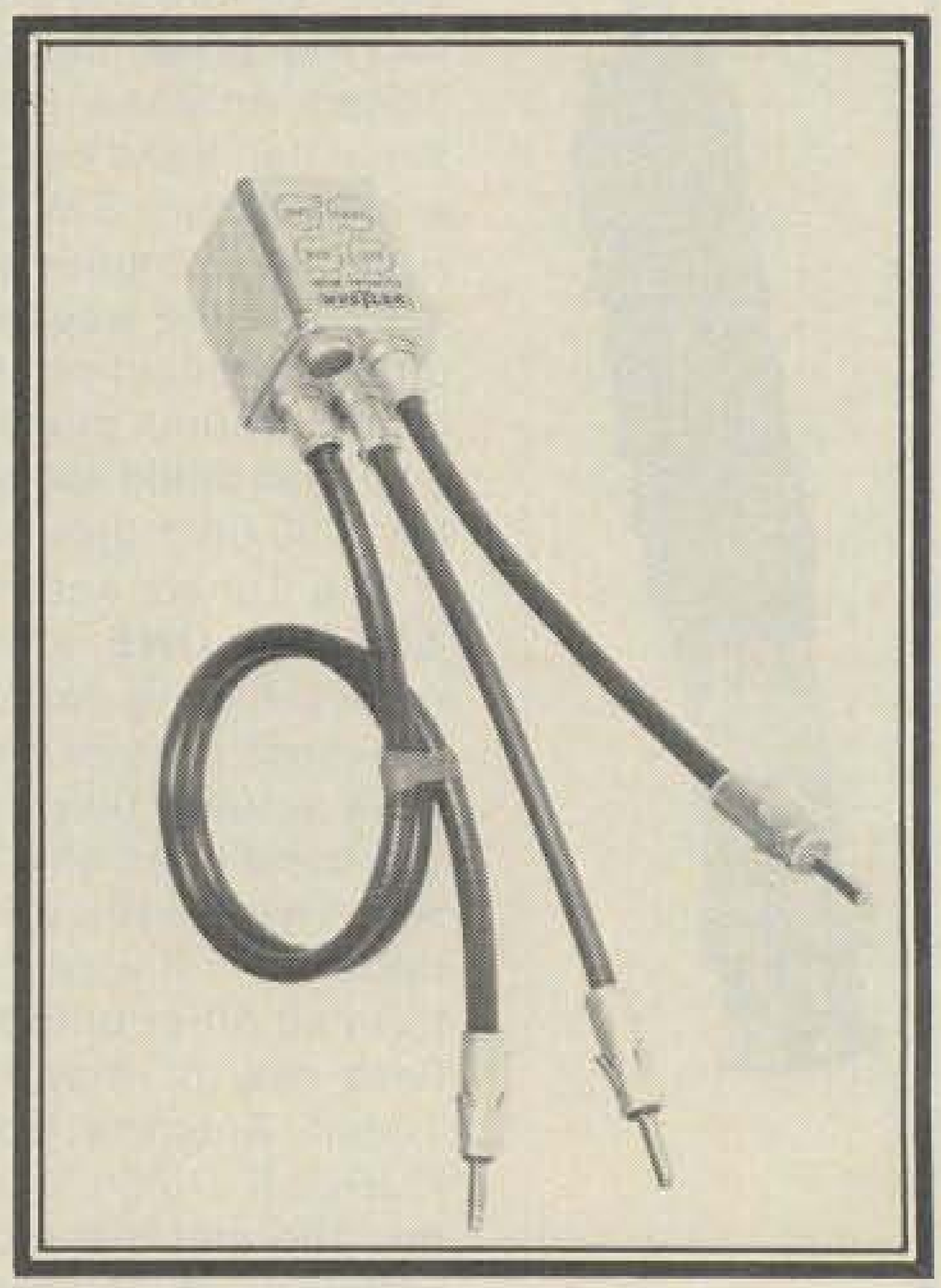
*317 Poplar Drive, Millbrook, AL 36054



Interesting scanner beam pioneered by Bob Grove, WA4PYQ, is shown here. Designed primarily for wide-band 108–512 MHz scanner coverage, gain over a reference dipole approaches 8 dB at several points, average v.s.w.r. is 1.92:1, and front-to-back ratio is 15 dB. A log-periodic type, it has a 250–300 ohm feedpoint impedance, which can be fed with standard low-loss coax using a standard TV-type balun transformer. Though designed primarily for monitor applications, the antenna also works on the 144, 220, and 432 MHz bands. (Photo courtesy Grove Enterprises, Inc.)

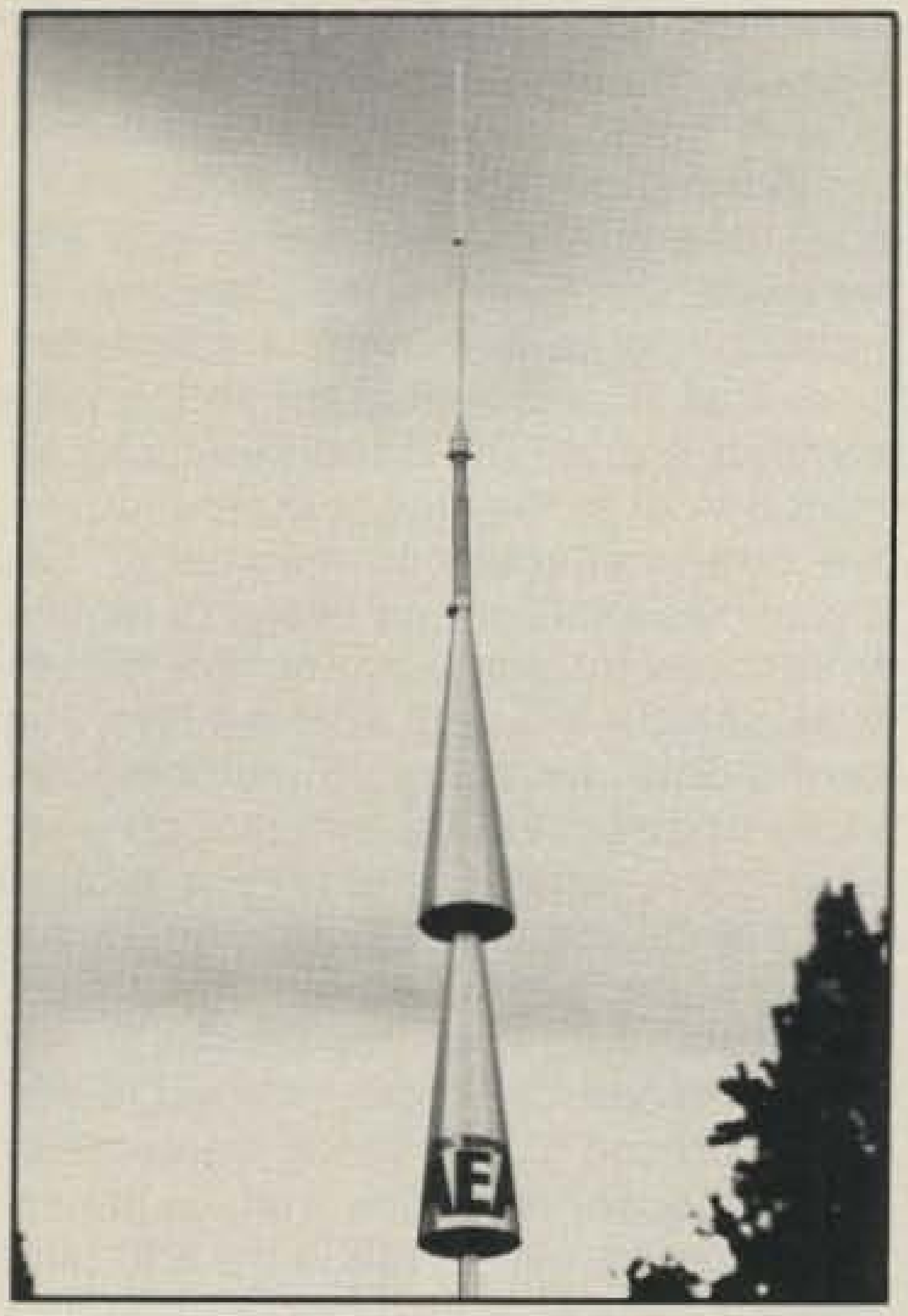
If one wishes to stick with an indoor antenna—often all that can be used under apartment- and condominium-style living conditions—better results can be obtained using a much longer adjustable whip, which may allow some compensating "gain." Radio Shack (among others) sells indoor scanner monitor antennas that are a notch above the simple telescoping whips usually furnished with scanners. For example, they sell one center-loaded v.h.f.-lo duo-band model that extends from 16–40 inches, and a combination v.h.f./u.h.f. triband model that is somewhat shorter.

Another possibility for improved indoor reception is to use one of the gain-type telescoping whips designed for use with 2-meter handi-talkies. One particularly good unit is the VoCom 5/8-wave collapsible 2-meter gain antenna (available from VoCom Products Corp., 65 E. Palatine Rd., Suite 111, Prospect Heights, IL 60070). This is a 10-section adjustable whip that can be extended up to 47 inches (5/8 wavelength on 2 meters); a combination base spring coil matching network terminate in a BNC-type connector. Although intended for 2-meter work, the antenna can be resonated at any frequency from about 143 MHz to 450 MHz by adjusting the length of the whip in ac-



Representative r.f. "splitter" for mobile applications allows scanner having separate v.h.f. and u.h.f. inputs as well as standard auto radio to be fed with a single antenna. (Photo courtesy Hustler, Inc.)

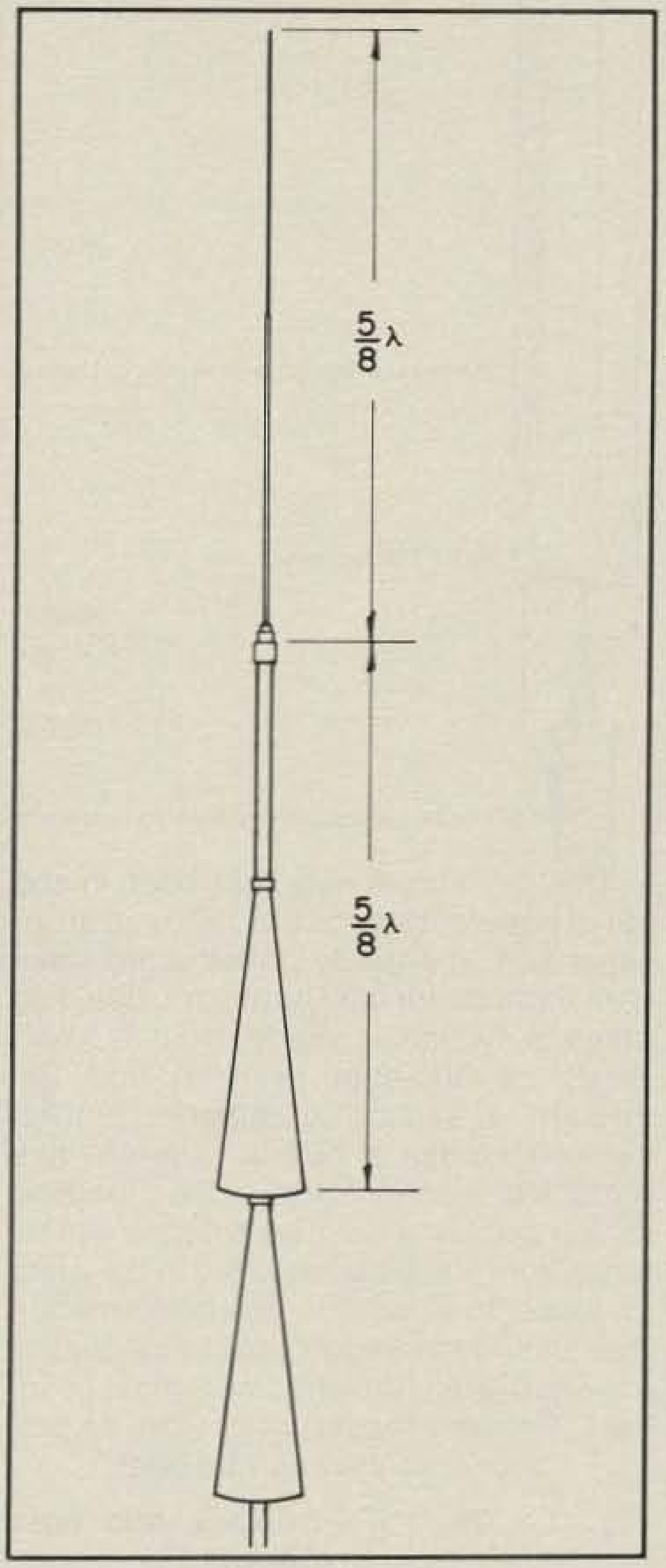
Antenna Of The Month: AEA IsoPole And IsoPole Jr.



The AEA IsoPole. (Photo courtesy Advanced Electronic Applications, Inc.)

Interesting vertical antenna design for the 2- and 1¼-meter bands is the AEA IsoPole, shown here. The antenna shown features a ⅝-wave radiator and dual decoupling sleeves. According to the manufacturer, the unusual design allows reduction or elimination of r.f. currents induced onto the antenna support structure and coaxial feedline shield and allows realization of a true 6 dB gain over a typical ¼-wave groundplane antenna. The antenna, a sketch of which is shown here, features extremely wide bandwidth (less than 2:1 s.w.r. over the 2-meter band), a beam pattern independent of feedline length, and power handling capability up to the legal power limit. The 5-pound antenna is about 125 inches long and mounts on a standard TV-type mast (not supplied by the manufacturer).

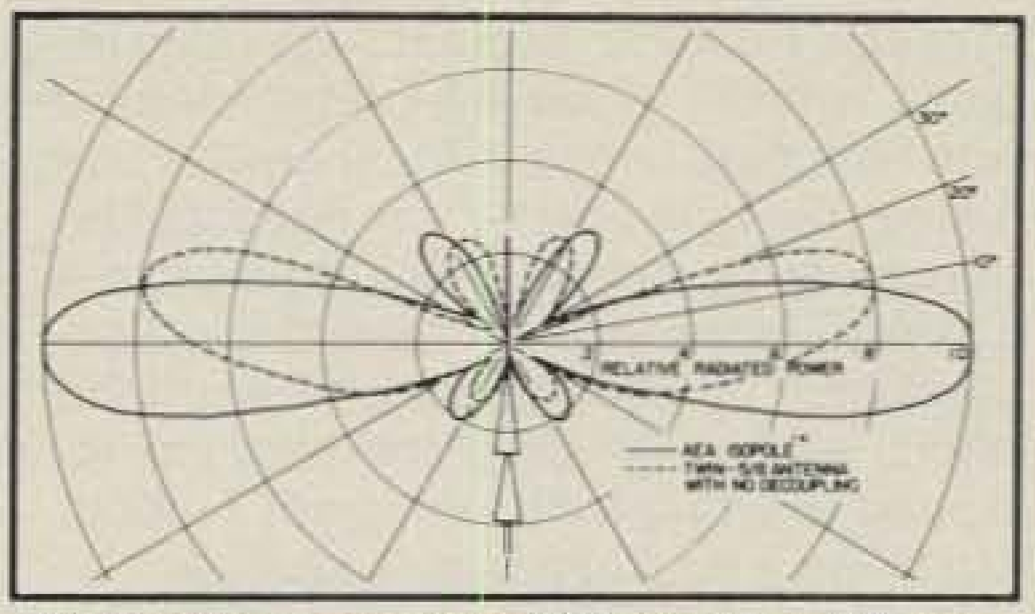
The author has had an IsoPole in the air at his QTH for about a year and has found it to be a very good performer, particularly from an operating bandwidth standpoint. The antenna works quite well



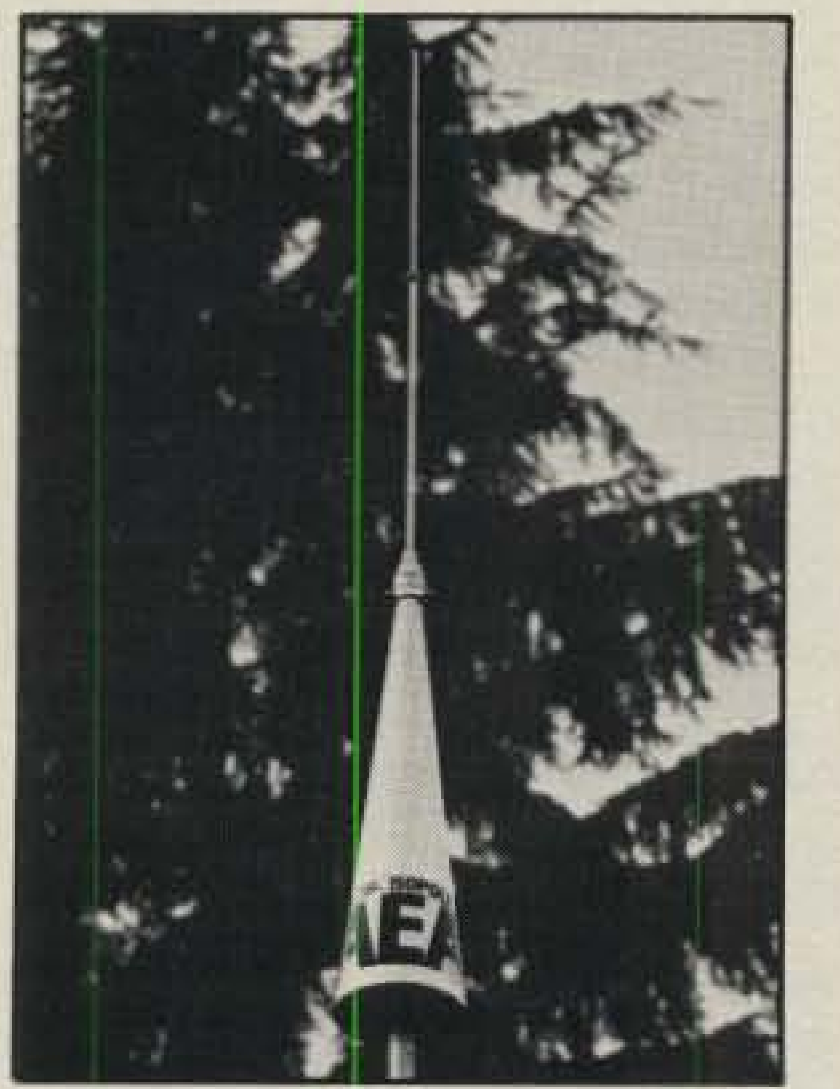
Sketch reproduced from the booklet "Facts About Proper VHF Vertical Antenna Design," copyright 1979 by Advanced Electronic Applications, Inc.

with the author's Bearcat BC-300 scanner for general purpose monitoring.

A new version of the IsoPole shown in the photo is the Isopole Jr. which is an end-fed half-wave dipole with a single decoupling sleeve. The antenna, which is about 64 inches long when tuned to 146 MHz, has about 3 dB less gain than the



Radiation patterns of AEA IsoPole™ compared to that of non-decoupled twin-⅝ antenna.



The AEA IsoPole Jr. (Photo courtesy Advanced Electronic Applications, Inc.)

larger IsoPole, but has a broader beam width and operating bandwidth (about 10 MHz when centered on 146 MHz). Since the antenna is fed at a low current point, one decoupling cone is sufficient to provide decoupling to coax. The impedance matching network is factory tuned and weather sealed. The antenna, designed especially for emergency or portable operation, has a base impedance of 50 ohms. According to company president Mr. C. Mike Lamb, the IsoPoles should give a good account of themselves for scanner monitoring purposes over the range 110–174 MHz. This is especially true of the larger IsoPole, since the two ⅝-wavelength phased elements are always in phase regardless of frequency. The IsoPole Jr. shown here is also available in a 220 MHz (1¼-meter) version.

diameter cables such as RG-8 or RG-11 (or cables like the new "large-diameter-equivalent" RG-8X) should be used. Splices should be avoided.

A splitter can be used to connect a multiband antenna to a monitor receiver that has two antenna jacks (one for v.h.f. and one for u.h.f.). However, most scanners have a single input jack for all three bands, so that if separate v.h.f.-lo, v.h.f.-hi, and u.h.f. antennas are used, a coaxial switch or combiner must be used. Since almost all scanner manufacturers long ago standardized on the automotive-type "Motorola" connector, it may be necessary to use PL-259-to-auto radio (Motorola) type adapters in order to employ a standard coaxial switch for scanner antenna switching. Using the switch will probably result in less signal loss than the splitter/combiner, though if the scanner is of the kind that can intermix the various bands as it searches for signals (most are), the switch would be unsuitable since only one band's antenna would be available at a time.

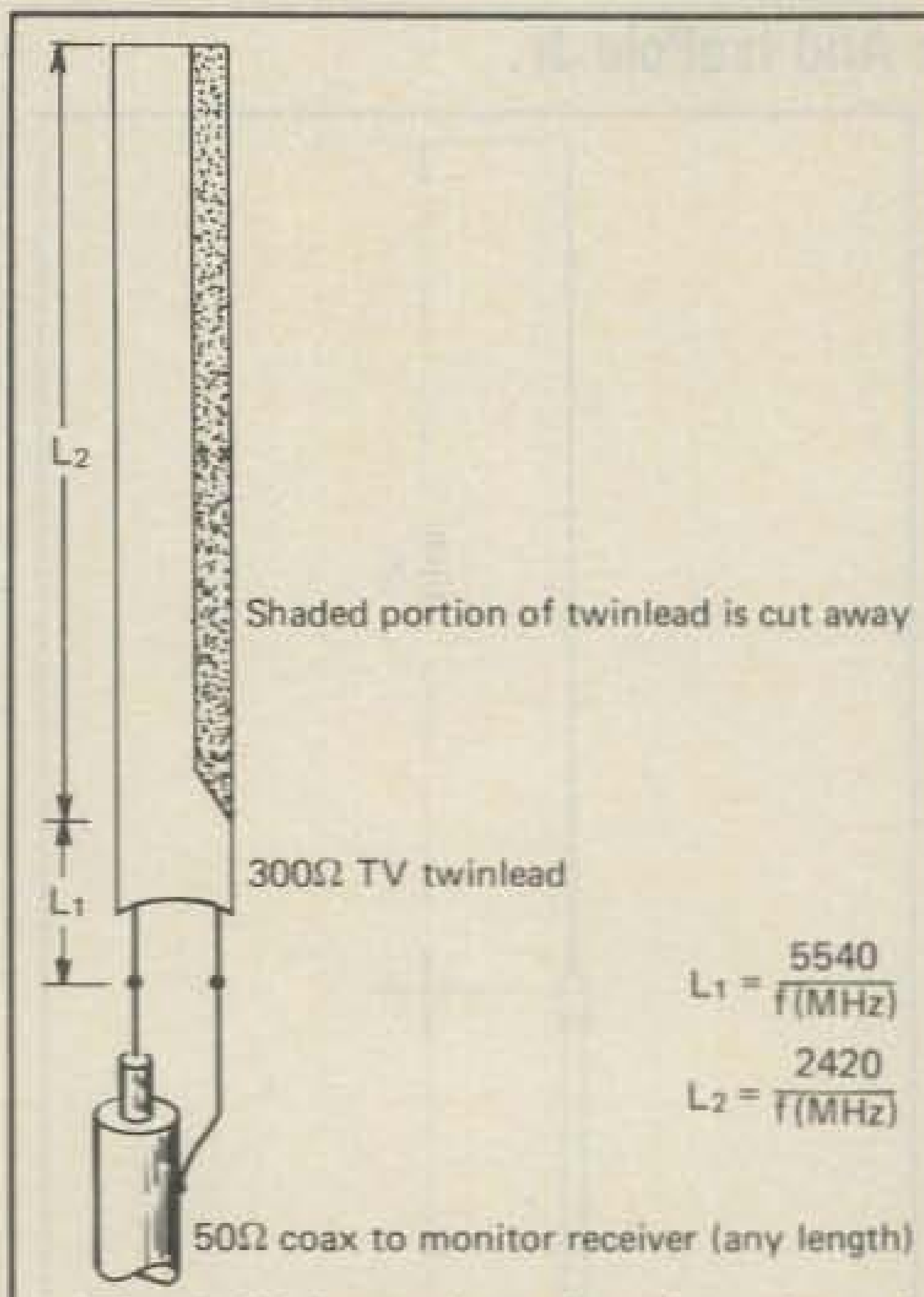
If more than one monitor receiver is to be fed by a single antenna, one possibility for simultaneously feeding the two sets lies in using HamTronics' P13 v.h.f. receiver multicoupler. The kit sells for about $19 and provides about 15 dB gain in each of the two output channels. If desired, outputs can be on different portions of a band with some reduction in gain. For example, the unit can drive a 2-meter receiver and a high-band monitor. A "lo" model covers 20–88 MHz and a "hi" covers 88–230 MHz. Write the manufacturer at 65 Moul Rd., Hilton, NY 14468 for more information.

Next month we'll discuss mobile antennas and special clubs and publications that serve the scanner enthusiast.

Until then, 73, Karl, W8FX

cordance with a special calibration chart available from the manufacturer upon request. In order to use this kind of antenna with scanners (which almost always use a Motorola-type connector), one must fabricate or purchase a BNC-to-Motorola adapter. However, the results for high-band v.h.f. monitoring are well worth the effort, especially when the antenna replaced is a relatively inefficient "rubber duck" on a pocket portable scanner.

For the apartment dweller, reception maybe considerably improved by home-brewing a vertical half-wave dipole made of fine wire, taped to a window, and fed with a short length of low-loss coax. If a window-mounted antenna is a possibility, Finco's MA-1WK represents a good choice for triband monitoring. The antenna, essentially a vertical dipole, comes with a window frame mounting bar that can be installed in a window up to 42 inches wide. An aluminum stand-off bracket positions the antenna well clear of the building for improved reception over indoor antennas. A homemade "J" antenna, as described in fig. 1, offers an additional—and inexpensive—possibility.



The "J," shown here, has been in and out of popularity since the 1930s as an inexpensive and easily constructed resonant antenna for v.h.f. and u.h.f. use. The antenna, which is made from a short length of 300-ohm twinlead and fed through a section of 50-ohm coaxial cable, includes a built-in quarter-wave matching section for good feedline match and low s.w.r. The antenna can be hung from a ceiling, installed in the attic, or taped to a window for performance that should markedly outdistance that of the short whip furnished with most scanners. For best results, of course, an outdoor antenna can't be beat.

Fig. 1– The "J"—a quick and easy monitor antenna.

Base Station Antennas

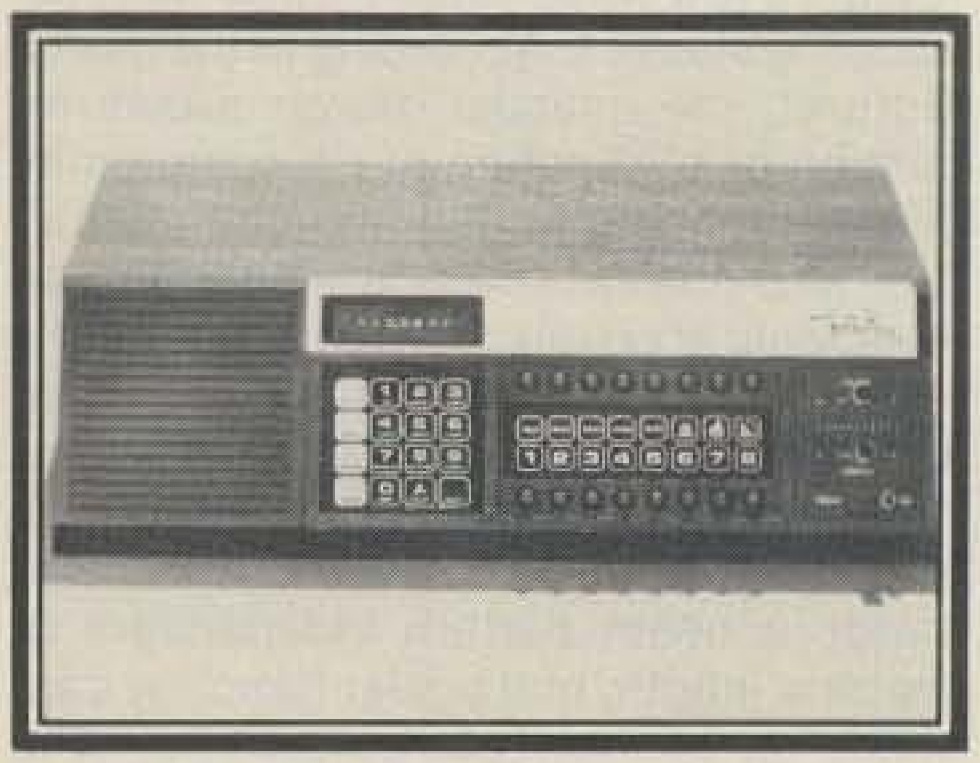
An outdoor antenna will dramatically improve reception range as well as the quality of reception. Since almost all monitor-band transmissions are vertically polarized, the basic scanner antenna takes the form of a single- or multi-band ground plane, although beams and other specialized antennas, such as the discone, are often used.*

Actual antenna choice depends upon a number of considerations including the band to be covered—v.h.f.-lo, v.h.f.-hi, and u.h.f.-t, or a combination of these—as well as the cost and complexity that one is willing to entertain. For general monitor purposes, an all-purpose vertical dipole may provide satisfactory reception of the entire 25–175 MHz spectrum. A good example is Avanti's "Ramrod" AV-160, a unity-gain dipole that can be adjusted to half-wavelength resonance anywhere within this range for reception of low or high band, TV/f.m., aircraft, marine, business, or amateur signals. The antenna can also be used in a nonresonant mode for general v.h.f. coverage, and it can be hung horizontally as well.

Bear in mind that a simple, quarter-wave ground plane will have a slightly "negative" gain with respect to a half-wave dipole. On the other hand, a 16-foot v.h.f.-hi collinear may provide 4.5 dB gain, while a 13-foot u.h.f. collinear will yield up to 7.5 dB gain. In particularly difficult areas, or if reception of a specific distant v.h.f. or u.h.f. station is desired, it may be useful to install a Yagi beam; using a TV antenna rotator will add a good deal of versatility. For most applications, v.h.f.-lo beam dimensions are a bit large for all but the most serious scanner buff, but reduced high-band v.h.f. and u.h.f. dimensions make multi-element arrays not unreasonable for gains of 10 dB or more. Installing a gain-type antenna can be quite rewarding; an antenna sporting 6 dB gain will double the signal strength at the receiver's antenna terminals, while a 10 dB gain antenna will increase strength by a factor of 10:1.

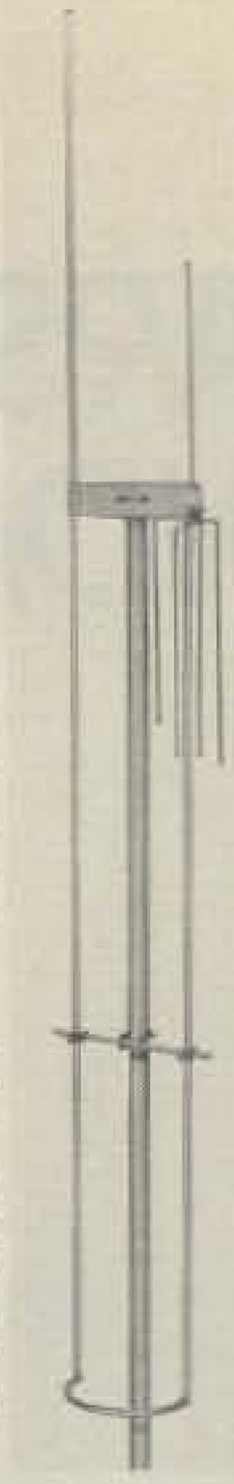
It's possible to cut down commercial TV and f.m. antennas for monitor use, as long as the antenna is mounted vertically. But an interesting, designed-for-application scanner beam has been developed by Bob Grove, WA4PYQ, which he sells through his firm, Grove Enterprises, Inc., Route 1, Box 156, Brasstown, NC 28902. The seven-element array, which is of the log periodic type for unusually broadband reception over the entire 108–512 MHz range, features gain over a dipole of 8 dB at several points and an average s.w.r. of under 2:1. Front-to-back ratio is 15 dB, useful in suppressing co-channel interference. Although its basic design results in a 250–300 ohm feedpoint, a standard TV-type balun transformer allows use with ordinary low-impedance, low-loss coax. The antenna also works on the amateur 144, 220, and 432 MHz bands.

Many of the latest scanners cover an extremely wide frequency range, placing a heavy demand on the antenna to adequately cover all the bands included in the scanner's capabilities. As a result, one little-known antenna that is receiving renewed attention is the *discone*, its name being derived from a solid-sided cone that is surmounted by, and insulated from, a disc. The discone, which can match most of the new scanners' coverage on a "megahertz-for-megahertz" basis, allows excellent coverage of almost the entire v.h.f. and u.h.f. monitor ranges with a single, efficient antenna involving no feedline switching or matching devices whatsoever. The antenna consists of a cone, which serves as a ground plane or decoupling sleeve for the coaxial feedline, capped by an element that is connected to the center connector. Its pattern is omnidirectional, similar to that of the ground plane. There's essentially no fixed upper reception limit, so the antenna can be used even in the 800 MHz range. However, there is a low-frequency cutoff, the point below which the antenna rapidly loses its effectiveness. This point occurs when the base and side dimensions of the cone are less than one-quarter wavelength, and the disc diameter less than about two-thirds wavelength.



Sophisticated state-of-the-art scanner by Regency, the K500 shown here, has 591 channel reception capability, comprising 551 preprogrammed channels (ROM) and 40 RAM. Featuring synthesized frequency selection and LED digital readout in search and scan modes, the unit covers 35–50, 144–174, and 440–512 MHz. Other unusual features of interest to the serious scanner buff include "service search" capability, priority channel activation, weather alert, digital count for number of activated RAM channels, self-contained clock, etc. Multiband, single-feedline antennas are particularly suited to wide-range scanners. (Photo courtesy Regency Electronics, Inc.)

**Antenna Columns on h.f. verticals, which appeared in September through November 1980 CQ, offer some solid information on vertical antenna theory and information. Much of the h.f.-oriented material applies to v.h.f. and u.h.f.*



Avanti Astro Scan AV-801 is a tri-band scanner monitor antenna with an unusual configuration. Designed to work into a single feedline, the antenna covers the 25–50, 140–174, and 450–512 MHz public service bands as well as the 2-meter amateur band. Several active elements make up the antenna—a co-inductive ⅝-wave "astro plane" for the lower band, with a 4.4 dBi gain claimed by the manufacturer; a half-wave dipole for the mid-band, with a 2.1 dBi gain; and a 1½-wave collinear on the high (u.h.f.) band. S.w.r., which is not a critical specification for scanner antennas, is under 1.5:1. The antenna is 10′ 2″ long and weighs 2.25 lbs; it works into 50–52 ohm coaxial cable. (Photo courtesy Avanti Research and Development, Inc.)

For considerations of size, most discones are designed with a lower cutoff limit of 30–40 MHz. For the scanner enthusiast, several companies make these useful antennas. One of the long-time favorites is Hustler's inexpensive Model DCX, which is designed for general-purpose reception in the 40–700 MHz range (though it should also work at slightly lower and higher frequencies).

Another unique and highly compatible commercial base station antenna is Avanti's "Astro-Scan" AV-801, a 10-foot triband antenna that covers the major scanner ranges of 25–50, 140–174, and 450–512 MHz. This unusual antenna, actually three separate antennas rolled into one, was reviewed in the November–December issue of *Science & Electronics*, and repeated in the 1981 edition of the *Communications World* handbook. As reported, the antenna seemed to do an excellent job, as advertised, on all the monitor bands. It also worked well on the 6-meter amateur band and the 27 MHz CB range, where s.w.r. was found to be surprisingly low. The antenna's design places the entire frame at DC ground potential for static dissipation and lightning protection.

Regardless of the type of antenna selected, it should be installed as high as possible. A "height gain" factor comes into play on the v.h.f. and u.h.f. bands which will dramatically increase reception range as height is raised, particularly in hilly or mountainous country. The antenna should be mounted free and clear of all obstructions such as wiring, metallic objects, trees, telephone lines, and the like.

Because scanner antennas are lightweight and of reasonable dimensions when compared with their lower-frequency counterparts, it's usually not much more difficult to install them than it is to erect a TV antenna. In most instances, a single section of steel or aluminum TV mast is good enough for rooftop or chimney mounting; a short tripod tower can also be used. It's also possible to mount the scanner antenna on the same tower or mast as a TV antenna, in which case the scanner antenna is installed above the TV antenna. There will be some interaction and mutual pickup of interference between the two receivers. But this should be minimal since the TV antenna is horizontally polarized while the scanner antenna is vertically polarized, and at least the scanner antenna is fed with shielded (coaxial) cable. Of course, since monitor antennas are omnidirectional, they require no aiming, unless a beam is used.

Particularly on the higher v.h.f. and u.h.f. ranges, the choice of coaxial cable is almost as important as the antenna itself. Losses in the transmission line, which can be substantial at these frequencies, can more than offset any gain provided by the antenna. For example, if antenna gain is 5.5 dB and the total cable loss is 4.5 dB, the *net* antenna gain is but 1 dB; roughly, each dB of cable loss will reduce signal levels by about 10%.

Thus it pays to buy a good grade of coaxial cable—certainly not cable of the CB type, which is notorious for its "thin" braid shielding and high-loss dielectric. Small-diameter, styrofoam insulated RG-58 and RG-59 communications-type cables, or RG-6 cable TV coax, should be good for runs of about 100 feet or so on v.h.f. For longer runs, and at u.h.f., large-

a monthly feature by
KARL T. THURBER, JR., W8FX

Antennas

DESIGN, CONSTRUCTION, FACT, AND EVEN SOME FICTION

More Information For Scanner Buffs

This month we pick up our discussion of scanner equipment with some thought on mobile scanner antennas. Scanners and s.w.l. topics have become very popular among non-amateurs and amateurs alike. It seems that we all like to listen in and eavesdrop on what's going on.

Mobile Scanner Antennas

The same considerations hold true for selecting and installing a mobile antenna as apply to the base station antenna. An important question is, shall I use an existing a.m./f.m. antenna, or install a special monitor antenna?

The separate monitor antenna will work best in almost all cases, particularly if a "standard" a.m./f.m. antenna is used—that is, one with no special provisions for simultaneous use as a monitor antenna. For close-range, strong signal reception, use of the car's existing a.m./f.m. antenna will probably be satisfactory if it is of the kind whose radiating element is not grounded, and if a special signal splitter is used to electronically feed the separate receivers and minimize interaction between their antenna circuitry, or if a BC/monitor coax switch is used. Bear in mind that automotive antennas are often fed with special coax that may not be suitable for v.h.f./u.h.f. work, and that may result in high signal attenuation. It's worthwhile, too, to play with the antenna's length, if it's adjustable. For v.h.f.-lo reception, the whip should be extended to full length, whereas for high-band reception, the whip is telescoped down to about 18 inches or so. A v.h.f./u.h.f. antenna cut for an adjacent amateur band will usually give a good account of itself.

A simple quarter-wave 18-inch whip can be used for mobile v.h.f.-hi monitoring, while a small 6-inch whip should do the trick for u.h.f. reception. A 49-inch ⅝-wavelength v.h.f.-hi antenna will provide about 3 dB of signal gain; much higher gains are possible on the u.h.f. bands using collinear and other complex designs.

*317 Poplar Drive, Millbrook, AL 36054

Designed primarily for amateur 2- and 1¼-meter operation, the AEA Isopole can be used to good effect as a scanner monitor antenna. Two-meter unit shown works as a monitor antenna from about 110–174 MHz, since the 5/8-wave decoupling sections are in-phase at all frequencies. A smaller antenna, which uses but a single decoupling cone, and is known as the Isopole Jr., can also be used as a general-purpose v.h.f. monitor.

There are a number of possible mounting locations. The best spot is the one that's as high as possible, which is the center of the vehicle's top. This location also provides the best ground plane for omnidirectional reception. Two other good locations, from an effectiveness standpoint, are the trunk lip and fender cowl, although the latter may expose the antenna to undue ignition noise. Bumper mounting is least preferred, due to the distorted ground plane configuration and low height. Permanent-type or magnetic mounting are best, while gutter clip and other temporary lash-ups are inefficient and should be avoided.

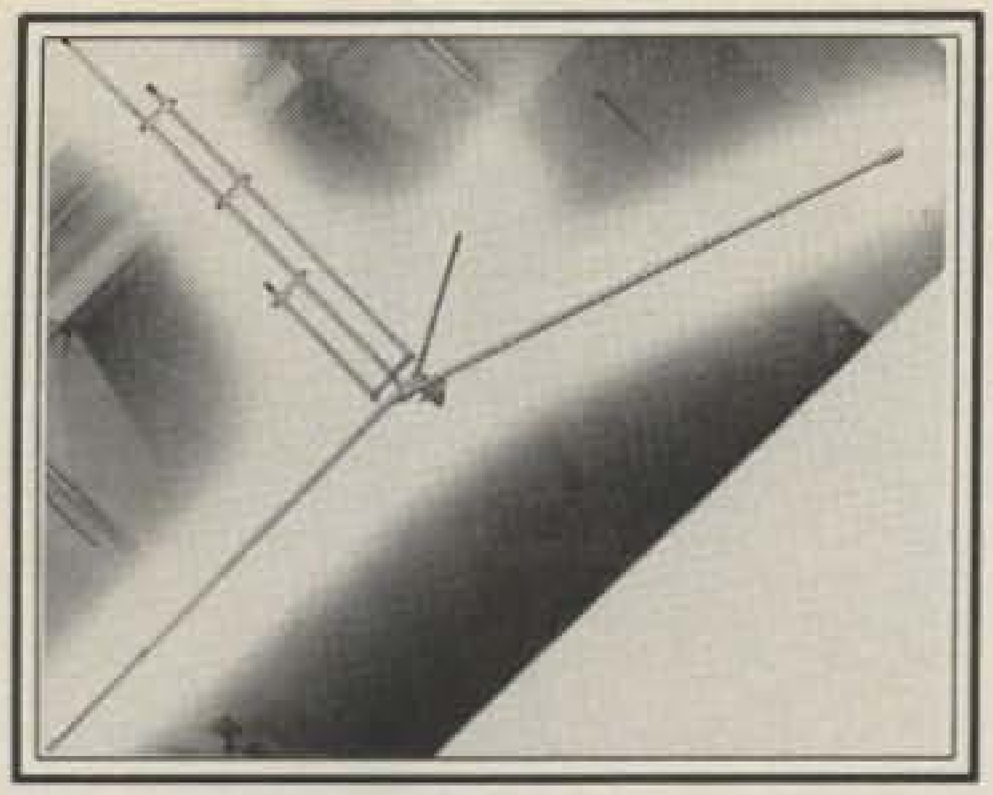
From a practical standpoint, probably the most desirable all-around mobile antenna for the multiband scanner is the combination v.h.f.-lo/hi/u.h.f. triband whip mounted on the car's trunk lid. A number of manufacturers, including Radio Shack and Antenna Specialists, make a variety of such antennas in trunk-lip and magnetic-mount models.

In most instances, the scanner is installed in the car in the same fashion and at the same place as it would be in any other rig—under the dash or on the transmission hump. Normally, the coax feeding the antenna (typically about 17 feet of RG-58/U) as furnished by the manufacturer has a very small and acceptable loss—typically under 1 dB on the v.h.f.-lo band, 1 dB on v.h.f.-hi, and about 3 dB on u.h.f. bands. These losses are normally not sufficient to worry about in a receiving installation.

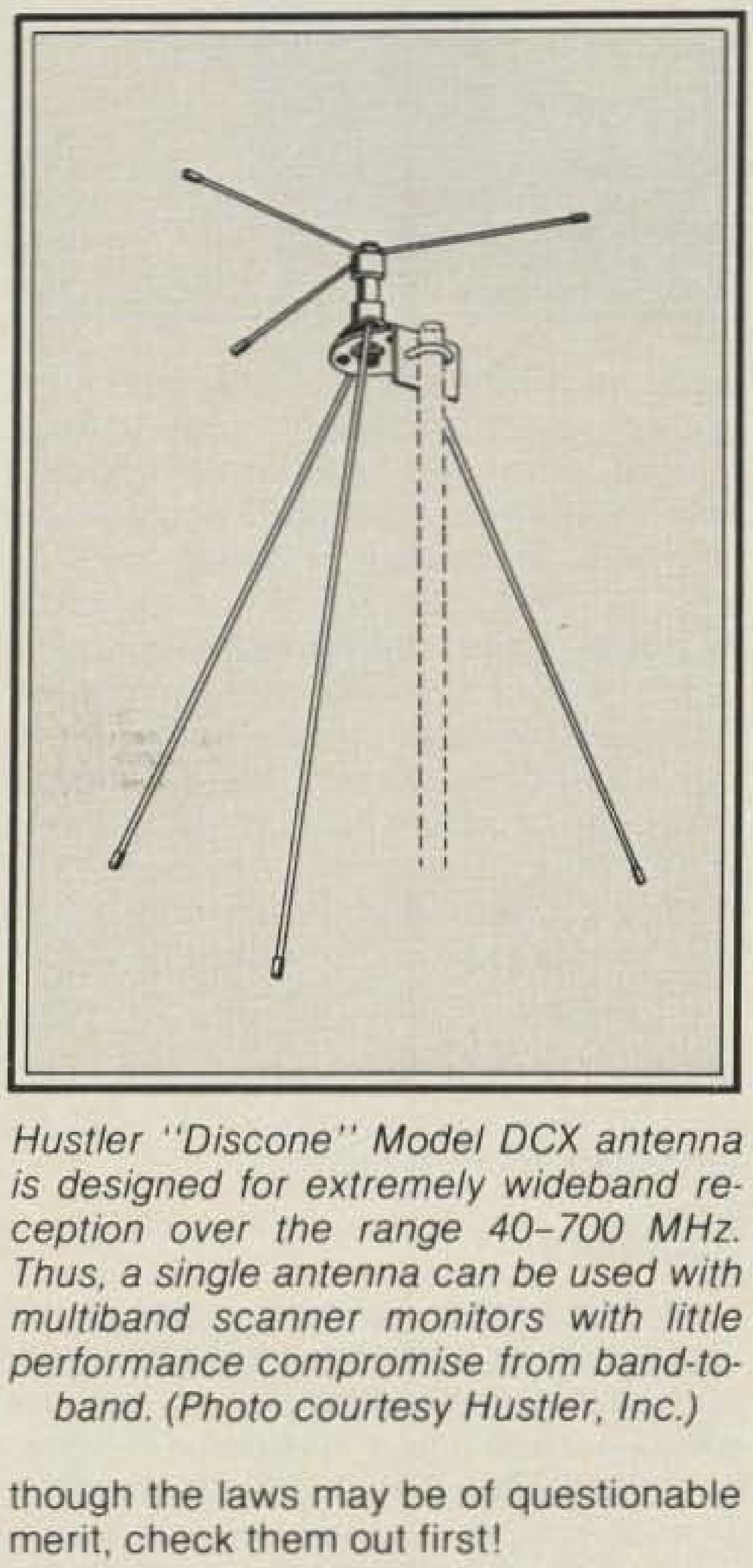
The multiband antenna can be connected to the single antenna jack which most scanners now use. If separate (dual) antenna jacks are provided on the scanner, a special antenna combiner may be used to properly split and route the signals from the single antenna. Alternately, if separate v.h.f and u.h.f. monitor antennas are used, a combiner may be used to accept the signals from the separate antennas and electronically combine them into a single scanner input, as in base station installations.

Although almost all public service monitoring uses f.m., with its inherent noise-free reception, ignition noise may still present a problem, particularly on the v.h.f.-lo band (30–50 MHz), and less so on the higher ranges. Noise may be particularly troublesome with forward-cowl monitor antennas, or if the standard cowl-mounted a.m./f.m. antenna is used for monitoring. A noise suppression kit may be required—one designed specifically for v.h.f. mobile use, since suppressors designed for the a.m. broadcast band are not normally effective at v.h.f.

A final point: Be sure to check with your local authorities before installing a scanner rig in your vehicle. Many states and municipal jurisdictions have laws or ordinances prohibiting the use of a mobile receiver that can receive police calls. Al-



Radio Shack multiband scanner antenna is a simple design that enables 3-band (v.h.f.-lo, v.h.f.-hi, and u.h.f.) reception with a single antenna. Unit consists of three separate whips optimized for reception on each of the 3 bands and 3 radials. (Photo courtesy Radio Shack)



Hustler "Discone" Model DCX antenna is designed for extremely wideband reception over the range 40–700 MHz. Thus, a single antenna can be used with multiband scanner monitors with little performance compromise from band-to-band. (Photo courtesy Hustler, Inc.)

though the laws may be of questionable merit, check them out first!

Special Clubs and Publications

With the recent surge in public service band monitoring, there has been a corresponding upswing in interest in organizations devoted to promoting scanning as a serious hobby.

One of the best known of such specialized radio clubs is the **Radio Communications Monitoring Association (RCMA)**, P.O. Box 4563, Anaheim, CA 92803. RCMA is for persons interested in listening to two-way communications in the v.h.f./u.h.f. public service bands as a hobby, primarily in the 30–50, 118–174, 225–400, 406–420, and 450–513 MHz ranges. The club was formed in May 1975 in order to share ideas and pool information of common interest. RCMA differs from most other listening-type groups since its focus is on *non-skip* reception of local radio systems, with emphasis on message content. A member organization of the **Association of North American Radio Clubs (ANARC)**, a confederation of the best-established hobby-listening clubs, RCMA is probably the oldest group of organized monitor radio listeners in the world. It draws its membership from a wide cross-section of enthusiasts, including amateurs, engineers, law enforcement officers, firefighters, and pilots. The group publishes a bulletin, the *RCMA Newsletter*, a sample copy of which is available for \$1. The club has more than 1300 members in 49 states and 8 foreign countries. At this time, U.S. dues are \$10.50.

For the sophisticated s.w.l. who wants to roam the higher frequency ranges, the Bearcat 220, shown here, allows monitoring of all the public service ranges plus the a.m. aircraft band. Up to 20 frequencies may be scanned at the same time. In addition to "normal" scanner functions, where frequency limits are set and the scanner searches between programmed parameters, it also searches marine or aircraft frequencies by depressing a single button. These frequencies are stored in memory, so no reprogramming is required. Other state-of-the-art features include priority channel and dual scanning speeds. (Photo courtesy Electra Co., div. of Masco Corp. of Indiana)

A newer club, the **Scanner Association of North America (SCAN)**, was formed several years ago with a tie-in to the Electra Company, manufacturer of the well-known Bearcat line of scanners, and REACT, the CB public service organization. The club's charter states that SCAN is "dedicated to the advancement of scanner monitoring and to the mutual understanding between citizens, public safety officials, and government." The organization, which boasts more than 30,000

The transmission line should be selected with the same care as the antenna. The best is expensive, but usually well worth the added investment. Losses in the line depend primarily on the cable's conductor sizes and types of insulation. Top-quality cables have polyfoam insulation, 100% braid shielding, and non-contaminating construction. RG-8/U and RG-11/U cables are "standard" in amateur use, although new, high-quality small diameter cables such as RG-8X are becoming popular and are about the same size as the RG-58/U shown here. (Photo courtesy Radio Shack)

Broadband monitor antenna covers three major scanner bands: v.h.f.-lo, v.h.f.-hi, and u.h.f. On the lowest band the 22-inch long design is an inductively shortened ¼-wave; on the mid-range, the radiator is a standard ¼-wave; and on the highest range, the whip acts as a ¾-wave collinear. Avanti AV-808 antenna shown here includes a trunk mount; the whip-and-coil assembly is also sold separately. (Photo courtesy Avanti Communications, Inc.)

members, issues a quarterly magazine, *Scanning Today*, and sponsors a frequency information service to provide members with lists of frequencies for their particular area. It also promotes a technical advisor service, which uses volunteer SCAN member technical experts to help fellow members solve problems or answer questions at the local level. SCAN also sponsors a buyer's co-op service as well as a free classified ad service. More information can be obtained by writing to SCAN at Suite 1212, 111 E. Wacker Drive, Chicago, IL 60601.

The new "smart," synthesized scanners make searching for unknown or unpublicized frequencies fairly simple. Still, it's helpful to have some idea of the local frequencies likely to be heavily "trafficked" to avoid searching in the blind for signals of interest. Several publications are available for this purpose and are essential for those using crystal controlled scanners, which require that target frequencies be known.

Bearcat publishes a comprehensive set of frequency directories. These volumes are published in two versions: one for the eastern time zone, and another for the central and western time zones. Area-wide listings make it easy to locate frequencies of interest among police, fire, emergency, aircraft, railroad, and other services, which are conveniently grouped by listening area. A reference section, fold-out FCC frequency allocation chart, 10-code chart, legal responsibilities section, and log book are included. Current price of each edition is about $13 at this writing.

Another valuable reference source for scanner buffs, s.w.l.'s, and professional communications agencies is the *Federal Frequency Directory*, a massive book containing 100,000 frequencies, agencies, and locations of active U.S. Federal Government communications assignments in the 2–420 MHz spectrum. The book, which provides authoritative listings, is available for about $15 from CQ's Book Shop.

The "Police Call" frequency directories, costing about $6 each and containing about 10,000 listings apiece, are available in nine state groupings and are distributed by Radio Shack. In addition, a number of specialized scanner directories covering government, aeronautical, and energy and environmental users are available from Gilfer Shortwave, Box 239, Park Ridge, NJ 07656.

There are also a series of scanner frequency guides put out by CRB Research, each designed for a particular area of interest. These, too, are available from CQ's Book Shop.

We should like to caution, again, that although scanner monitoring is good fun for all and a serious hobby for many, listeners are reminded to observe the restrictions of the 1934 Communications Act, which forbids the disclosure of, or personal benefit derived from, the interception of a radio transmission not intended for them to hear.

Bearcat "ThinScan" 4-band, 6-channel pocket portable scanner is representative of advanced monitor technology. Unit shown here allows reception on any mix of 6 channels in 4 bands (v.h.f.-lo, v.h.f.-hi, u.h.f., and u.h.f.-"T" bands). It scans the six crystal-controlled channels at the rate of 15 channels per-second and has a built-in scan delay. Another scanner in the pocket-portable line allows dual reception of both v.h.f.-a.m. aircraft and u.h.f.-f.m. channels on the same unit. (Photo courtesy Electra Bearcat div. of Masco Corp. of Indiana)

Summary

In this series, we have covered the wide range of scanning equipment available to the casual and serious listener alike—with special emphasis on the new-breed models with their attendant sophistication but more demanding antenna requirements. We have shown that the choices of monitor antennas are many, and run the gamut from the small indoor antennas furnished with most units, to complex, multiple-resonant verticals and wideband discones. Hopefully, this sampling of information will provide you with some insight into scanner receiver and antenna interface applications and considerations.

Next month, we will discuss a subject that's dear to the DXer's heart, one that's even synonymous with "antennas" to many: the *Yagi*. See you then.

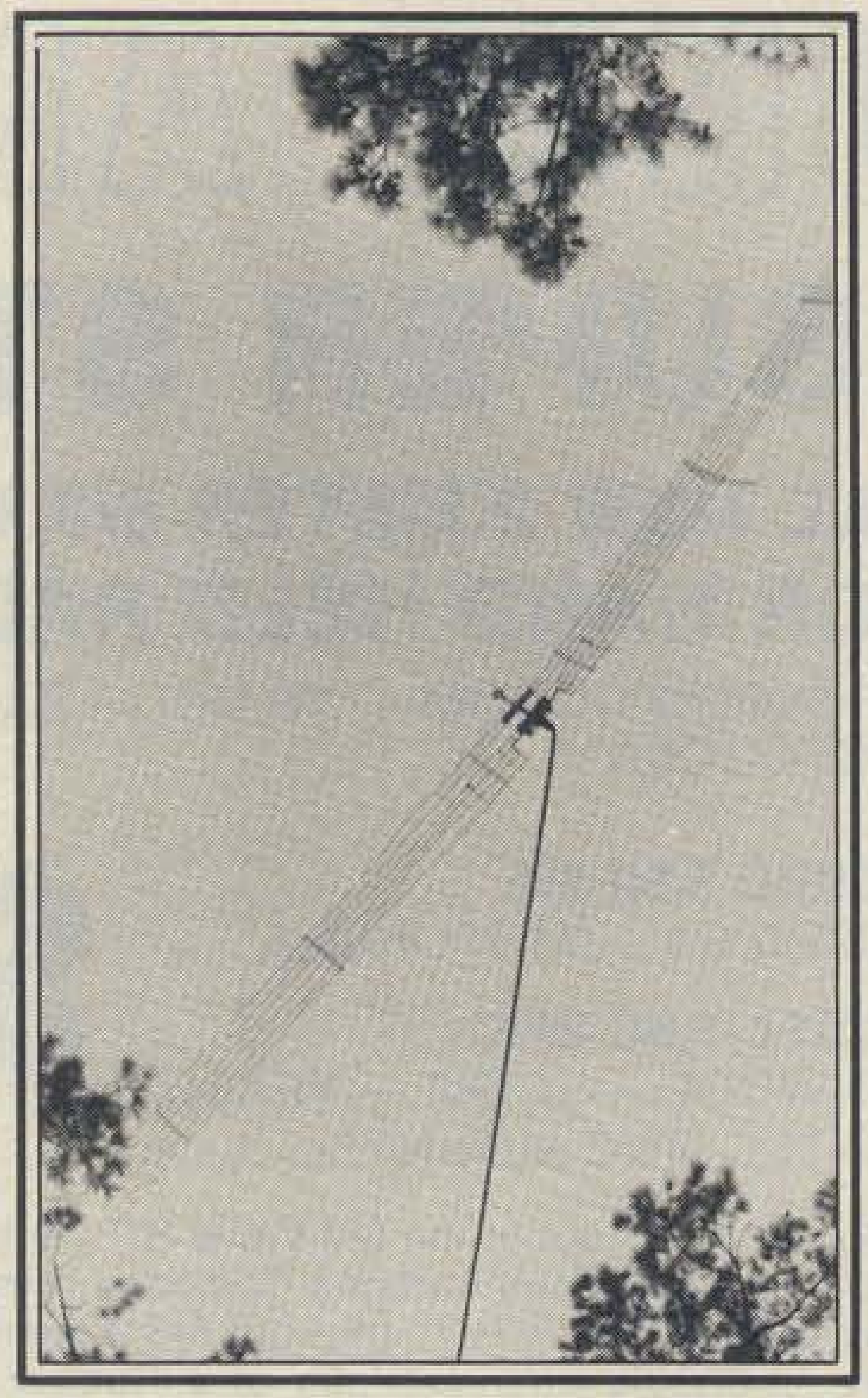
73, Karl, W8FX

Antenna Of The Month
The Mor-Gain Multiband H.F. Communications Antennas

The Mor-Gain series of multiband dipole antennas represents an unusual approach to the problem of obtaining efficient and effective operation on several h.f. bands. Using no traps, loading coils, or tuning networks, the antennas—available in about a dozen versions—are one-half the length of conventional dipoles, are designed for low-s.w.r. feed with a single coaxial feedline, and handle 2.5 kw c.w. or PEP s.s.b.

In production for amateur and commercial use for more than 15 years, more than 20,000 of the antennas have been made to date. The amateur "HD" dipoles are of commercial/industrial grade, originally designed for s.s.b. point-to-point applications, and are re-engineered versions of the commercial counterparts. Of the same quality and reliability as the commercial models, they feature unbreakable insulators and stainless steel hardware.

The "HD" antenna design is of a patented, proprietary origin. It's based on the combination of a number of "wrap-around" dipoles that are paralleled, or combined, into one so that only two or three (for inverted Vee operation) suspension points are required; a single feedline is employed. Little in the way of tuning is required, although resonant frequencies can be altered by adjusting various "U" tabs or shorting bars.



Mor-Gain "half-size" h.f. multiband dipole as installed at the author's station. Five-band antenna shown here is 66 feet long and is fed directly with 75-ohm coax. A single feedline is used for operation on all bands.

A number of models are available, allowing operation on various combinations of bands from 80 through 10 meters, including specialized models for Novice band operation. An important feature is that the antennas are half-size; for example, an 80- through 10-meter "HD" is between 66 and 69 feet long, as opposed to up to 135 feet for a full-size dipole on 80 meters. An antenna tuner is not required for operation, but may be desirable to help transmitter loading on band edges, where the s.w.r. may become a bit ragged in some cases.

Perhaps the most versatile of the series, and the one which your Antennas Editor uses, is the 75-10 HD/A (SP) model. This particular antenna is designed for 75–10 meter operation, is optimized on 75 meters at the mid-band point (about 3800 kHz), and comes with a built-in SO-239 coaxial connector, supplied at a slight extra cost.

Prices range up to about $85 or more for the larger antennas. They are available from Mor-Gain, 2200 South 4th St., Leavenworth, Kansas 66048.

a monthly feature by
KARL T. THURBER, JR., W8FX

Antennas

DESIGN, CONSTRUCTION, FACT, AND EVEN SOME FICTION

It's every amateur's desire to have his signal heard as best he can, and to be able to hear everything he wants to hear. For most h.f.'ers, the Yagi probably represents the best overall choice in antennas to realize these goals. In this series, contributing editor W8FX summarizes the case for the Yagi.

Last month, we went back to 1926 to discuss the origins of the Yagi, or more properly, the Yagi-Uda, antenna, recounting highlights of the life and times of the eminent Japanese engineer and scientist, Dr. Hidetsugu Yagi, and his colleague, Dr. Shintaro Uda.

In this and upcoming columns, we will bring ourselves up to modern times with a discussion of the Yagi as it's used on h.f. today. First we will review the dipole in its central role relative to the Yagi. We will cover basic parasitic element design principles, and discuss two-, three-, and multiple-element arrays. Later, we will highlight the multi-band (trap) Yagi, discuss beam construction and installation, and cover feeding, matching, and tuning. We'll also review important "Quad vs Yagi" considerations and present some useful beam operating tips.

Let's look first at the dipole and how it relates to the Yagi.

The Basic Dipole

It's important to briefly review the dipole's characteristics for three reasons: (1) the dipole is probably the simplest and most common form of h.f. antenna in use today; (2) it's a highly useful standard of reference; and (3) the dipole element constitutes the basic "building block" of the Yagi array, particularly as the driven element.

The dipole has two arms (poles) separated by a center insulator and connected to one another by means of the transmission line. Normally made of wire, but often of tubing or rod (as in the Yagi), the dipole is a resonant half-wavelength antenna; its overall length is cut to about 5% less than one-half of the "free space" wavelength of the frequency for which the antenna is designed. The length is determined by the formula

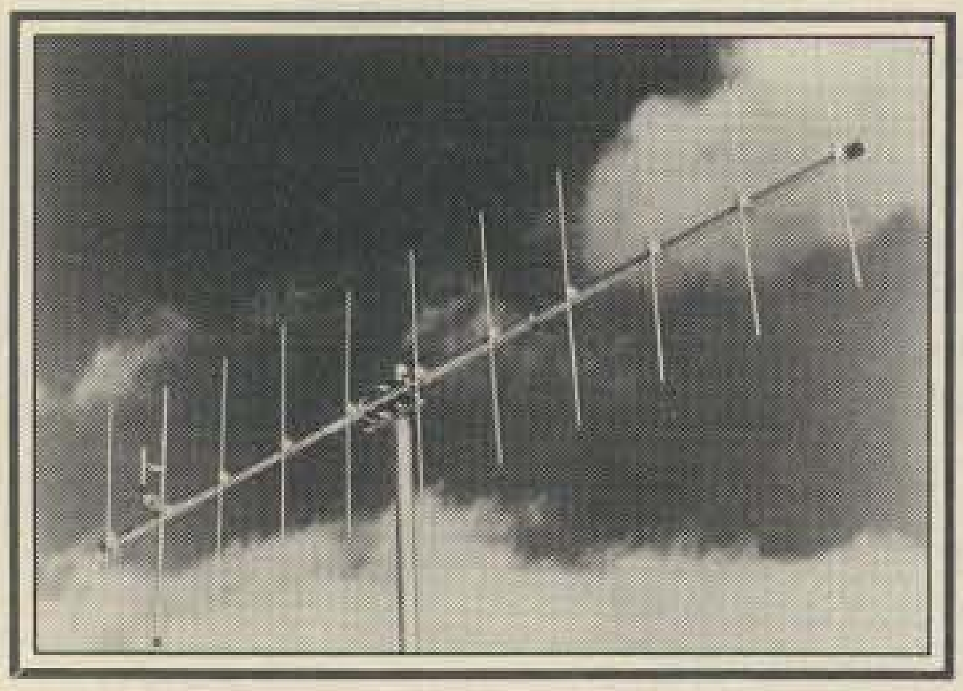
$$L = \frac{468}{f}$$

In this formula, **L** = length in feet and **f** = frequency in MHz. On the h.f. bands, dipole lengths range from about 253 feet for 160-meter (1850 kHz) operation, down to about 16 feet for 10-meter (29 MHz) work.

In the simple dipole, the wire is cut exactly in the middle of the span and a transmission line is attached at the center point. The ends of the dipole and the two halves are insulated so that there is no electrical connection between them and other objects.

The theoretical radiation resistance (feedpoint impedance) of the half-wavelength wire dipole is in the vicinity of 72 ohms, although this will vary with height above ground and other factors. The dipole is balanced with respect to ground—that is, both sections of the antenna are symmetrical. Feeding the balanced antenna with 72-ohm transmitting twin-lead is fine, although due to its expense, loss, and potential for feedline radiation, coaxial cable has largely replaced it. In practice, the dipole is usually fed with one of several types of 50- to 75-ohm coaxial cables. The smaller RG-58/U (53-ohm) and RG-59/U (73-ohm) varieties are fine for medium power levels and short runs on the h.f. bands, but they are not designed for high power. Also, losses rise significantly with high s.w.r.'s and with increasing frequency. Larger, more efficient RG-8/U or RG-11/U should be used for best results. A new, small-diameter, low-loss, high-power cable known as RG-8X was introduced several years ago; it holds real promise for holding down the weight, bulk, and expense of the transmission line without sacrificing performance. A balun is often used at the feedpoint to allow direct feed with coax while retaining the balanced characteristic of the antenna.

In addition to the simple dipole, the *folded dipole* is a long-time favorite. It's similar to its ordinary cousin, except that it has a broader frequency response, and the feedpoint impedance is considerably higher—around 300 ohms. As the name suggests, it's a dipole that has been folded back on itself. Adding the top wire effectively quadruples the center impedance to 300 ohms, as opposed to about 70 ohms for the straight dipole. The folded dipole is a balanced, single-band antenna, although it—like the simple dipole—can be excited on odd harmonics. It can be fed directly with 300-ohm twin line through an antenna coupler or a set of balun coils installed at the transmitter, or fed with coaxial cable using a 4:1 transformer-type balun at the antenna. This kind of element is sometimes used as the driven element on Yagi arrays due to its exceptionally wide bandwidth characteristic. While the bandwidth of the ordinary dipole is typically about ± 2% of the design frequency for a 2:1 s.w.r., the bandwidth of the folded dipole is wider.



"Long" Yagis, generally impractical on the h.f. bands for reasons of size, can be put to good use on v.h.f. and u.h.f. bands. The 11-element Cushcraft Yagi in this photo has a claimed gain in excess of 11 dB over a dipole. The antenna's characteristic focuses radiation fairly narrowly to a 38-degree arc at the 3 dB points; larger, longer, or stacked beams will narrow the antenna's focus much more, requiring accurate positioning for consistent results. Four 11-element beams such as these can be stacked to form a "quad array" to yield a gain of better than 17 dBd. When this is done, 3 dB beamwidth is reduced to about 29 degrees. (Photo courtesy Cushcraft)

*317 Poplar Drive, Millbrook, AL 36054

Listed below are the power gain, expressed in decibels (dBs), of several popular Yagi configurations relative to isotropic (point) and dipole sources. The gain figures shown are typical, and are not meant to represent maximum or minimum possible or theoretical figures. Gain achieved in practice will involve a number of factors, particularly physical element spacing and overall boom length.

Number of elements	dB gain over half-wave dipole	dB gain over isotropic source
Half-wave dipole	—	2.1
2-element Yagi	5.0	7.1
3-element Yagi	8.0	10.1
4-element Yagi	10.0	12.1
7-element Yagi	11.0	13.1
10-element Yagi	13.0	15.1
15-element Yagi	16.0	18.1
20-element Yagi	19.0	21.1

Note: The larger Yagis listed above would, of course, normally be practical only at v.h.f. and u.h.f. frequencies and are shown for comparative purposes only.

Fig. 1– Yagi comparative gain table.

The dipole typically has a doughnut-shaped, bidirectional radiation pattern, with maximum radiation occurring at right angles to the axis of the antenna. Generally speaking, if the antenna can be mounted at least ¼-wavelength above ground, results will be satisfactory. Practically speaking, directionality is not usually too pronounced on the lower bands (80 and 40 meters), but "beam effects" can be significant on the higher bands. Under normal conditions, the practical difference between broadside and "off the ends" signal reports when using a half-wavelength dipole may be an S-unit (6 dB) or less on 80 and 40 meters, while on 15 meters and higher may reach two or three S-units. Those amateurs who can afford the space sometimes mount two dipoles at right angles to one another. By switching from one antenna to the other, a "rotating" beam effect can be obtained, which can be useful for DX.

For the most part you can do very well with the no-frills, coax-fed half-wavelength dipole on h.f. Despite its limitations, the dipole can be a very inexpensive, useful, and easy-to-install antenna that allows one to get on the air with minimum difficulty. Nevertheless, a very important difference between the station that "works out" and one that doesn't lies in the quality of the antenna system. While it's possible to obtain satisfactory results with minimal equipment, low power, and a simple dipole, just about everyone recognizes that the beam can act as a very potent power multiplier . . . thus enter the Yagi, the subject of this month's column.

Parasitic Element Operation

As related in a previous column, Drs. Hidetsugu Yagi and Shintaro Uda were the first to propose a type of antenna array that used a single driven element, closely coupled to "parasite," or parasitic, elements, the latter operating as either reflectors (as a result of inductive reactance) or directors (as a result of capacitive reactance)—depending on the length and spacing of these parasitic elements. The radically new designs were initially proposed for v.h.f., u.h.f., and microwave transmission by the Japanese scientists in the late twenties. It wasn't long after, however, that forward-looking engineers, scientists, and amateurs saw the Yagi's application at h.f. frequencies as a practical, efficient, and compact alternative to the Beverage, or wave, antenna—the then-standard antenna used when directivity was required in an antenna system. In the early thirties, the first really practical h.f. designs appeared in the radio and amateur press, but it wasn't until about 1938 that Yagis based on the now-familiar aluminum tubing design came to be known. In the early-to-mid 1940s, as aluminum became a more familiar, rugged, and inexpensive material, the Yagi truly came into vogue, with many pages in *QST* and *CQ* devoted to construction articles.

How does the Yagi work? The heart of the array is the driven element, which receives power directly from the transmitter through the transmission line. The other two key elements are the director and reflector, which constitute the parasitic elements. The length of the parasitic elements depends on whether they act as directors or reflectors.

The key is **reinforcement** of the radiated wave by the parasitic elements. It's easiest to understand Yagi operation by looking at the receiving case, where we have a dipole driven element and a director and reflector. The received signal is first intercepted by a parasitic element, which extracts energy from the radio wave and reradiates it. The dipole receives the signal directly from the signal source as well as from the parasitic element; the latter signal reaches the dipole slightly out-of-phase with the original signal.

The signal from the parasitic element, if the element is not connected to a load and the signal reaches the dipole at the right instant, will reinforce the signal received directly by the dipole. The director is placed "in front of" the dipole, while the reflector is situated "in back of" the dipole to perform similar functions but in opposite directions. Both kinds of parasitic elements provide signal reinforcement when adjusted properly in terms of spacing and length to ensure that the reradiated energy reaches the resonant dipole in proper phase with the radio signal received directly by the dipole.

The dipole itself, which is resonant and terminated in a load, will enable energy to be extracted from it and be sent down the transmission line to the receiver. Not only will a significant power gain in a given di-

rection be realized, but signals from the side and rear of the array will be attenuated appreciably, thus affording a good deal of "physical selectivity" in reception. A similar phenomenon to that described takes place when transmitting, but in reverse: the transmitted signal is reinforced in the desired direction and attenuated off the rear and sides of the antenna.

In practice, the Yagi is typically referred to as a **beam antenna**—an antenna that has gain and has marked unidirectional characteristics. It is one that radiates energy mainly in one direction at the expense of other directions, much in the fashion of a flashlight's beam. The long-range potential of a good directional beam antenna is vastly better than that of an omnidirectional antenna, such as a vertical or vertical ground plane. A good beam can easily mean the difference between working stations that can't even be heard, much less worked, when using a simpler, non-gain-type antenna.

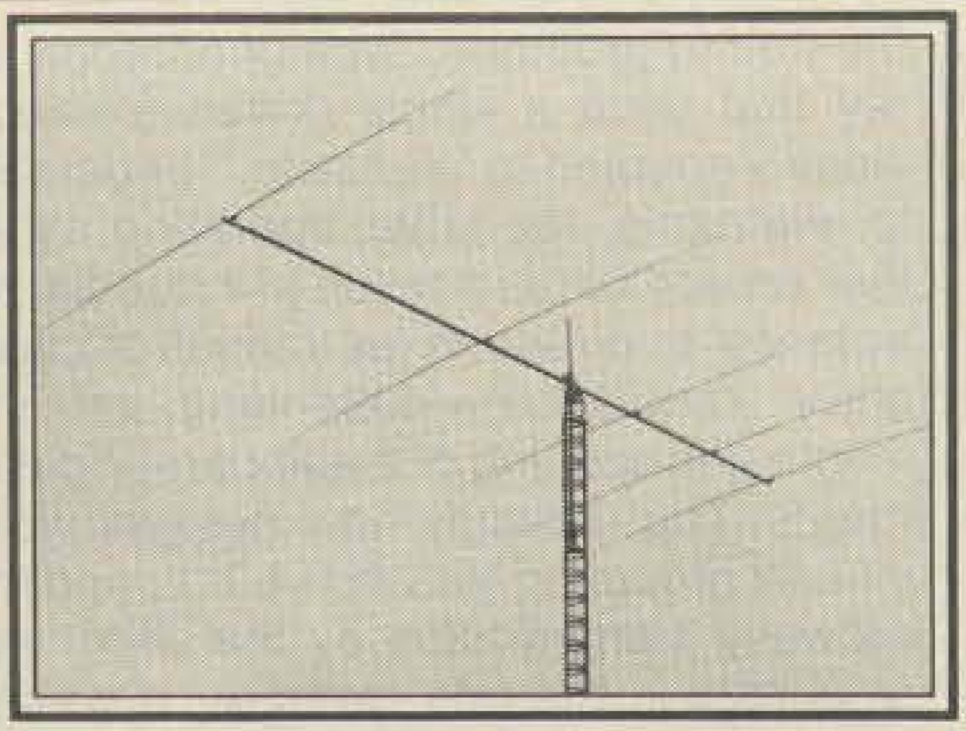
To this point, we have mainly spoken about Yagis in the abstract. Let's now look at practical two-, three-, and multi-element arrays.

The Yagi Beam

The advantages offered by the Yagi are well-known; an important difference between a station that "works out" and one that doesn't is usually found in the antenna being used. With a beam, it's often possible to obtain excellent, competitive results even if running low power and using simple gear. For top DX and contest work, use of a Yagi beam is usually necessary for top performance, and is second only to a few specialized antennas, such as the rhombic and some quads.

Both two- and three-element arrays are popular and efficient beam antennas. They can provide considerable power gain not possible with simple dipole and vertical antenna systems. The entire antenna is normally rotated to allow its directivity and gain—both on transmitting and receiving—to be focused on any desired point on the compass; the beam can be aimed (directors in front) in the desired direction for optimum performance. Yagis may be single-band or multi-band arrays; this month we will consider only the monobander. The arrays can be mounted either horizontally, with the plane containing the elements parallel to the earth, or vertically. Typically, the Yagi is polarized horizontally on h.f., v.h.f., and u.h.f. frequencies, although vertical polarization is popular on 10 meters, 11-meter CB, and v.h.f.-f.m., where communications with vertically polarized mobiles is common.

The two-element array is a good bet where space and mechanical considerations preclude the larger structure required for a three-element or larger array. Generally, the reflector is spaced about 0.15 wavelength from the driven element, though spacings as low as 0.1 wavelength are effective. Typical 2-element array gain is about 7.1 dBi, or 5.0 dBd, depending on spacing and other factors. Front-to-back (F/B) ratio is typically 12–15 dB.

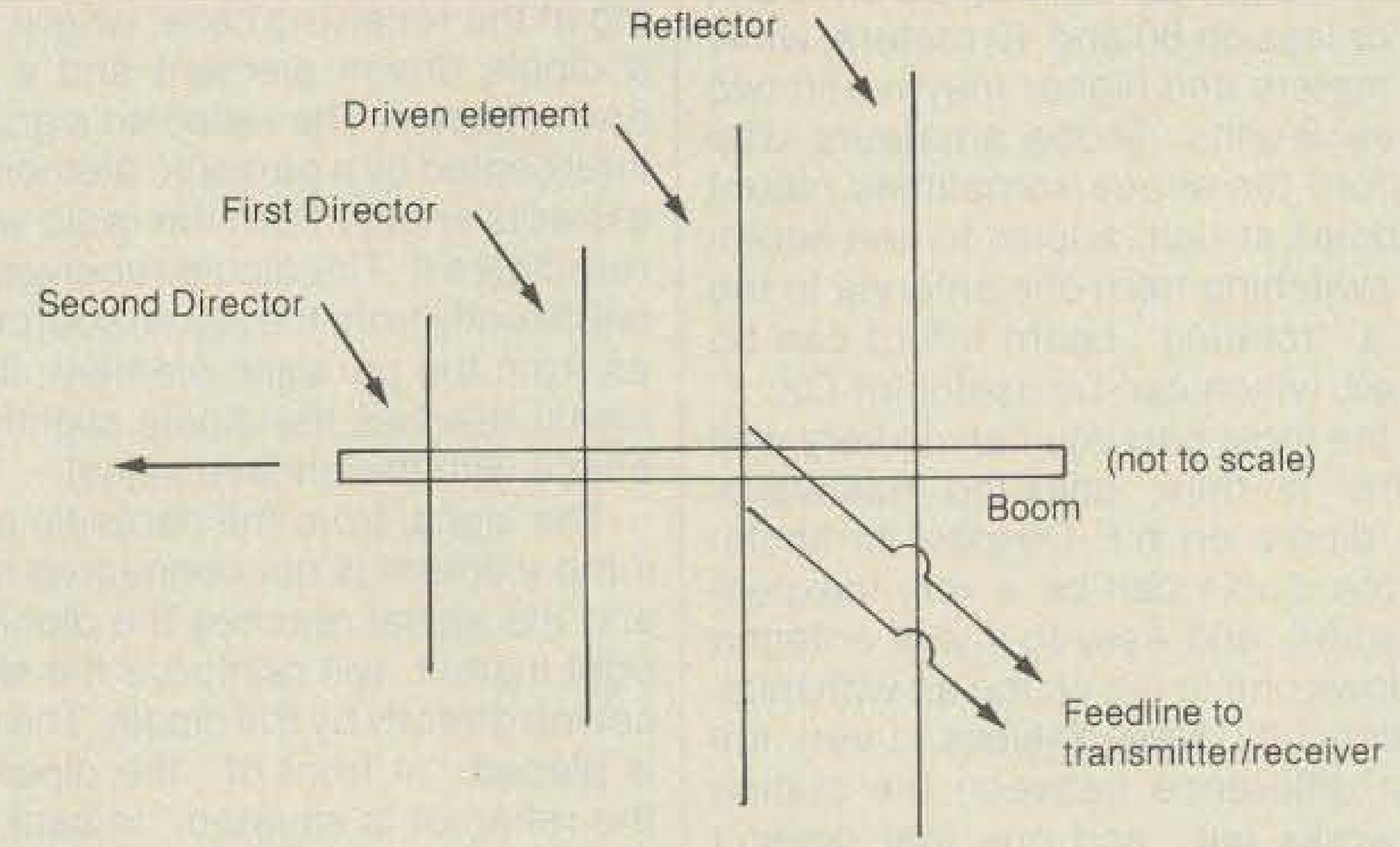


Departing from conventional Yagi design, KLM's 20-meter "Big Sticker" monobander has dual driven elements for a uniform gain over a considerable bandwidth and a high F/B ratio. The 5-element design pictured has a claimed gain of 9.7 dBd and an impressive 30 dB F/B ratio. The 65-pound antenna has a boom length of 42 feet 3 inches and a maximum element length of 37 feet. (Photo courtesy KLM Electronics, Inc.)

Probably the most popular beam is the three-element array, representing a popular compromise between the lower cost, gain, and size of larger arrays. The three-element array, with a director, driven element, and reflector, exhibits a typical gain of 10.1 dBi, or 8.0 dBd, depending mainly on spacing; F/B ratio usually runs 15–20 dB. Usual driven-element reflector spacing is in the range of 0.15 to 0.25 wavelength, with 0.2 wavelength representing a good compromise. Director spacing is relatively uncritical over a broad range of dimensions. So-called "wide" spacing of both directors and reflector is generally desirable from a gain, impedance matching, and tuning standpoint. But the mechanical problems occasioned by wide spacing on the lower bands, such as 20 meters, can introduce considerable construction difficulty. For this reason, overall boom lengths are usually constrained when designing beams for use on this band. Fig. 1 shows comparative forward gain figures.

Larger arrays are often practical on the higher h.f. and v.h.f./u.h.f. ranges. Generally speaking, the more elements, the better the performance. A four-element beam will afford more gain than will a three-element array, as long as the boom used will allow for at least 0.2 wavelength spacing between elements. Obviously, tuning for maximum gain or F/B ratio involves a number of interlocking variables, including element spacing, length of elements, and element diameter. A four-element array typically provides a usable gain of about 12.1 dBi, or 10.0 dBd, and an F/B ratio of 20–25 dB. A simplified diagram of a four-element array is shown in fig. 2.

Four-element and larger arrays present some special problems, particularly if element-to-element spacing is close (less than about 0.2 wavelength). With close-spaced arrays, the radiation resistance of the driven element may be very low, so low that ohmic losses in the conductor can consume a significant amount of power. The elements should



Sketch above shows a four-element Yagi, consisting of two directors and one reflector in conjunction with a driven (directly excited) element.

The elements may be either in the horizontal or vertical plane. The directors are made shorter than the driven element, while the reflector is slightly longer. The metal elements, usually made of aluminum tubing, are mounted to the boom by special brackets and mounting hardware. Inter-element spacings of 0.15 to 0.25 wavelength are commonly used.

The antenna system may be fed by breaking the driven element in the center and feeding in dipole fashion, or a Gamma match can be used. Using the latter feeding method allows the array to be at DC ground potential for better lightning protection.

Fig. 2– Simplified diagram, four-element Yagi array.

be made of heavy tubing (one-half to one inch in diameter): a conductor of large diameter has less ohmic resistance as well as lower Q—both factors being important in such antenna systems because of the low impedance involved. From a practical standpoint, while the four-element array can offer an improvement on reception and be sharper on transmit than smaller arrays, the advantages of having more elements may not justify the mechanical problems associated with optimum spacing, or the electrical problems caused by close spacing.

More About Gain And F/B Ratio

We've indicated that the parasitic array's gain is dependent on several interrelated factors, foremost among which is element spacing. For a given spacing, a tuning condition exists that will yield maximum gain. The gain "passband curve" is a bit lopsided, with more gain occurring on the high-frequency side of the design frequency and less gain occurring below the design frequency. For example, a three-element array cut for 14,150 kHz may show a 1 dB or greater difference in gain between frequencies 1% lower to 1% higher than the design frequency. Gain will drop off dramatically past these limits, notably as the resonant frequencies of the parasitic elements are approached. Gain eventually drops close to zero, about 3% off the design frequency of the driven element. The maximum operational bandwidth for a three-element Yagi is usually considered to be about ± 2% of the design frequency.

Maximum F/B ratio rarely coincides exactly with the condition that gives maximum forward gain; although the beam is usually tuned for maximum forward gain, in some cases the beam is actually tuned for maximum F/B ratio—an operator's decision. The F/B ratio curve is a very sharp one, and it deteriorates sharply at both ends of the usable frequency band. F/B ratio is also quite sensitive to boom length. F/B ratio can deteriorate or become erratic due to the electrical effects of nearby objects, including other antennas, especially as the array is rotated through the compass.

Since the impedance of the driven element varies with tuning and spacing, it's important to note that if the antenna system is to be precisely tuned, it's done *before* the match between the transmission line and the antenna's driven element is completed. Tuning and matching are interrelated, however, so it's usually necessary to go through several adjustment iterations to ensure that both matching and tuning are correct. For electrical convenience, grounding safety, and ease of tuning, most modern beam designs put the entire array at d.c. ground potential, with a gamma match used for matching the feedline to the array. More on matching and tuning later.

Frequency (kHz)	Driven Element	Reflector	First Director	Second Director
14050	33′ 5⅝″	35′ 2½″	31′ 9⅜″	31′ 1¼″
14250	32′ 11¾″	34′ 8½″	31′ 4″	30′ 8″
21050	22′ 4″	23′ 6″	21′ 2½″	20′ 9⅛″
21300	22′ ¾″	23′ 2⅝″	20′ 11½″	20′ 6¼″
28050	16′ 9″	17′ 7⅝″	15′ 11″	15′ 7″
28600	16′ 5¼″	17′ 3½″	15′ 7¼″	15′ 3⅜″

The table above shows nominal element lengths for a typical h.f. 4-element array using 0.2-wavelength inter-element spacing. For closer spacing, on the order of 0.15 wavelength, the length of each element is increased slightly. Use of 0.2 wavelength spacing results in wider bandwidth and slightly higher gain than if 0.15 wavelength spacing were used.

The table can be used to determine the element lengths needed, interpolating between the listed dimensions if compromise c.w./phone coverage is desired in the same array. The element lengths given also apply to two- and three-element beams.

Although a beam's tuning can be checked as part of the installation process, the dimensions shown in the table will generally be found to be close enough without resorting to further checking, unless optimization of either gain or F/B ratio is a must.

Fig. 3– Nominal element lengths for h.f. 4-element arrays (10/15/20-meter phone/c.w.).

Just what does a few dB of forward gain, or F/B ratio, mean in practical terms? A gain increase over the simple dipole or vertical is substantial, as it may, for example, mean a 6 dB gain, equivalent to a power gain of four times; this represents a full S-unit change on the receiving end. This is equivalent to increasing power from 100 to 400 watts, a substantial increase. As a result of this power multiplier effect, a good beam antenna, coupled with moderate to high power, often means the difference between working the rare DX station and not working it in a pileup. On the other hand, trying to squeeze out the last possible dB of antenna gain or F/B ratio, possibly going to a mechanically oversized array, is marginal at best. If you're in a DX pileup with hundreds of competing amateurs trying to work a rare station, it's doubtful that a 1 or 2 dB difference would help, and such a small increase just doesn't mean much in the real world of nuts-and-bolts antennas. A gain of 4–5 dB is in the "gray area," however, and might thrust your signal up over the noise and the competition and make it stand out.

A final point: The standard linear Yagi is by far the most common type of beam in use today. Although beyond the scope of this survey series, we should point out that it's possible to stack Yagis either in broadside or collinear fashion for added directivity and gain, although these techniques are applicable mainly on v.h.f./u.h.f. frequencies. The ARRL *Antenna Book* and other standard antenna texts have details.

Fig. 3 shows typical h.f. monoband beam antenna dimensions for a four-element array.

Summing Up

In this month's column, we highlighted the significance of the dipole, introduced parasitic element theory and operation as it applies to the Yagi, and covered various single-band beam configurations. In upcoming columns, we will continue the discussion, getting into multi-band or trap arrays; construction and installation; feeding, matching, and tuning; on-the-air techniques; and "which antenna is best" considerations. See you then.

73, Karl, W8FX

a monthly feature by
KARL T. THURBER, JR., W8FX

Antennas

DESIGN, CONSTRUCTION, FACT, AND EVEN SOME FICTION

The H.F. Yagi: Part II

Experience has shown the need for some sort of "signal multiplier" for successful h.f. DX operating: this multiplier usually takes the form of a rotatable Yagi. In this series, author W8FX gives us the plain-vanilla facts about parasitic beams for h.f. work. He continues with Part II in this issue.

Last month we began our technical discussion of the Yagi by going back to the simple dipole, following with a discussion of elementary parasitic element theory and operation. We continued with simple, single-band, two-element configurations and went on to more complex, multiple-element arrays.

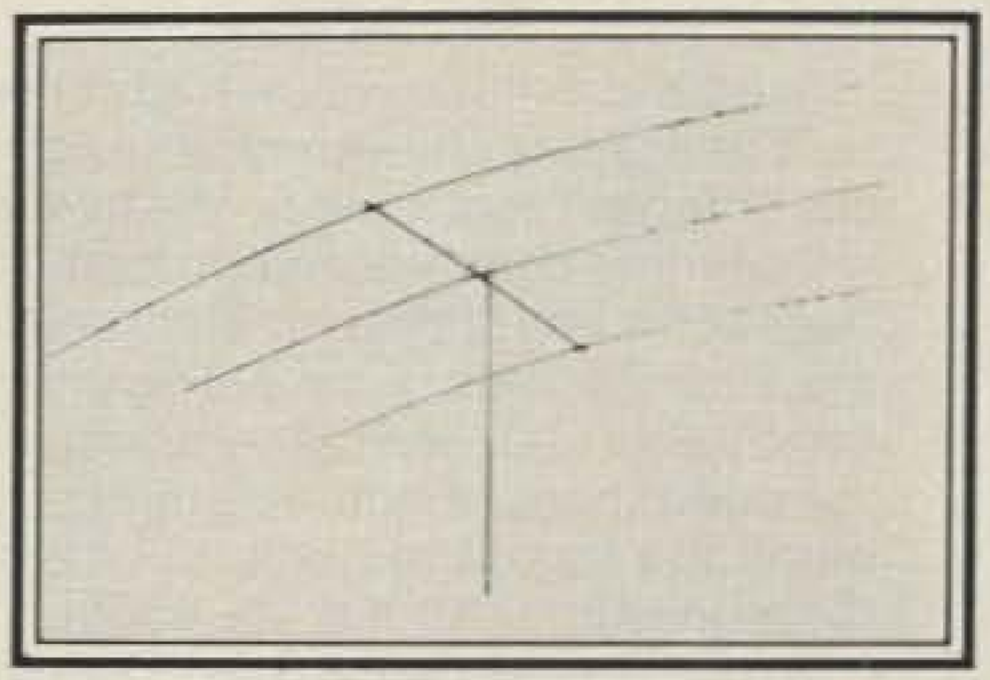
From our discussions, one thing is clear: the array Drs. Yagi and Uda envisioned was a single-frequency affair, with frequency excursions limited in scope. But the Yagi lends itself, like the dipole, to multiband operation using multiple-resonant circuits pioneered by people such as Howard K. Morgan in the early 1940s and Chester Buchanan in the 1950s. Out of their work grew the trap dipole and the trap Yagi, the latter being the subject of this month's column.

Let's first briefly review how traps work, then we'll talk about the multiband trap Yagi. Next month we will take up with a few words on the quad vs. Yagi controversy.

Trap Theory And Operation

It's a good idea at this point to review trap history, theory, and operation as it applies to the simple dipole. From there, it's not hard to relate traps to the multiband Yagi.

Very early trap experimentation and development is credited to an airline engineer who needed a simple multiband antenna that would provide good ground station reception of various h.f. signals. This man was Howard K. Morgan, who came up with what was essentially a centerfed dipole in which the end insulators were replaced with parallel-tuned circuits. These lumped constants, placed at specific points along the antenna, allowed it to simultaneously develop resonances on several discrete frequencies. Morgan published his early research in the August 1940 edition of *Electronics*. There was little amateur interest in traps in the 1940s and 1950s, however.



A logical extension of the basic trap dipole is the multiband trap beam, the most common form being the rotatable tribander covering 20, 15, and 10 meters. This design incorporates the same trap principles and concepts to resonate the director and reflector elements to give the array its directionality, gain figure, and front-to-back (F/B) ratio. Shown here is the Hy-Gain TH3JR three-band array. (Photo courtesy Hy-Gain Electronics)

In 1950, Chester Buchanan, W3DZZ, published an article in the old *Radio and Television News* on using tuned circuits in a beam, and later popularized them in a *QST* article. By the late 50s and early 60s, traps came into their own as a practical means of feeding a single dipole antenna (or beam driven element) with coaxial cable on several bands without manual bandswitching in the antenna system.

Today, the trap antenna is almost old-hat. Just about everyone acquires a bandswitching transmitter and receiver, or transceiver, covering from 160 or 80 through 10 meters. This wideband coverage promotes the search for a reasonably efficient, easily matched antenna system that will allow operation on most or all h.f. bands with a minimum of readjustment when changing bands. In the future, the trap will likely become even more important in view of accelerating trends to apartment and condominium living, small home lot size, and restrictive covenants or ordinances on land use that suggest that the minimum number and size of antennas serve one's amateur operating needs.

The trap dipole antenna, if designed and installed properly, can provide hassle-free multiband capability; the system will have essentially the same efficiency, radiation pattern, and characteristics as if erected as separate antennas. There *is* some loss in the traps themselves, although losses are usually minor when compared with overall possible *system* losses, such as from improper grounding, poor matching, feeder radiation, etc., often incurred with other types of multiband antennas.

The traps, in effect high impedance inductor-capacitor combinations, serve as a sort of "transmission line" that prevents r.f. energy from moving along the entire length of the antenna at the higher frequencies. Each lumped-constant trap is used in the antenna to divorce or decouple the remainder of the antenna flattop from the section on the inside of the traps—the portion nearest the feedpoint—as bands are changed. In that the L/C circuit poses a high impedance to r.f. current flow at its resonant frequency, it acts as a trap for r.f. so as to electrically "chop off" the antenna beyond that point. In effect, the trap acts as though it were the end of the antenna at that frequency. At all other frequencies above and below the trap's resonant frequency, the trap is a short circuit so that r.f. passes through it virtually unobstructed—simple, as a look at fig. 1 shows.

As we suggested, trap antenna efficiency is usually good. While the efficiency of the trap dipole may be *slightly* lower than separate dipoles for each of the bands (due to some trap losses and the fact that the traps are not absolutely perfect insulators), losses are not usually significant in a carefully adjusted multiband trap antenna using good quality, high-Q-factor traps. The traps themselves may be homebrewed, although commercial versions are relatively inexpensive and probably boast better mechanical and waterproof construction than the average amateur can manage.

There is little doubt that, as in *any* multiband antenna, traps involve some compromise. After all, six or more antennas may be rolled into one, and there is some price to pay for such convenience. Some

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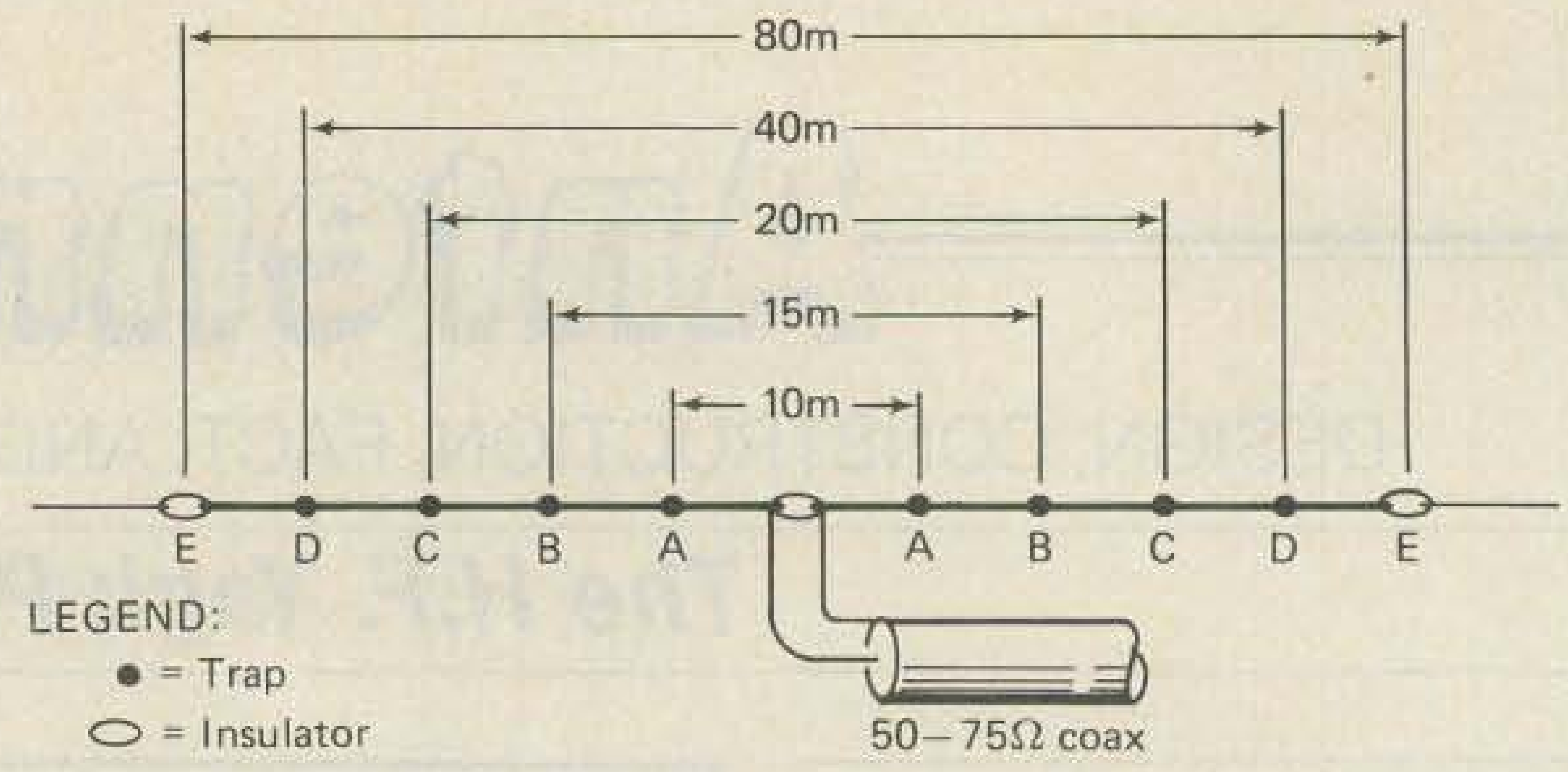


Illustration shows typical trap configuration in a five-band multiple-trap antenna. The antenna shown uses four pairs of traps, for a total of eight, for simultaneous antenna resonance on the five bands.

The innermost antenna section, A:A, makes up the 10-meter antenna. The traps at the end of this dipole section make up a resonant L/C circuit that isolates the outer portions of the antenna when working on 10 meters. The outer sections—B:B, C:C, and D:D—function in similar fashion for the lower bands. On the lowest band, which is 80 meters for this antenna, the full antenna (E:E) resonates as a half-wave dipole, but it is somewhat shorter than formula length due to the loading effects of the traps.

A five-band dipole can be constructed with as few as one pair of traps, but operation on the higher bands (20, 15, and 10 meters) is somewhat sporty, since the traps cause the antenna to operate in a harmonic mode on those bands, with actual resonance and resultant s.w.r. not easily predictable.

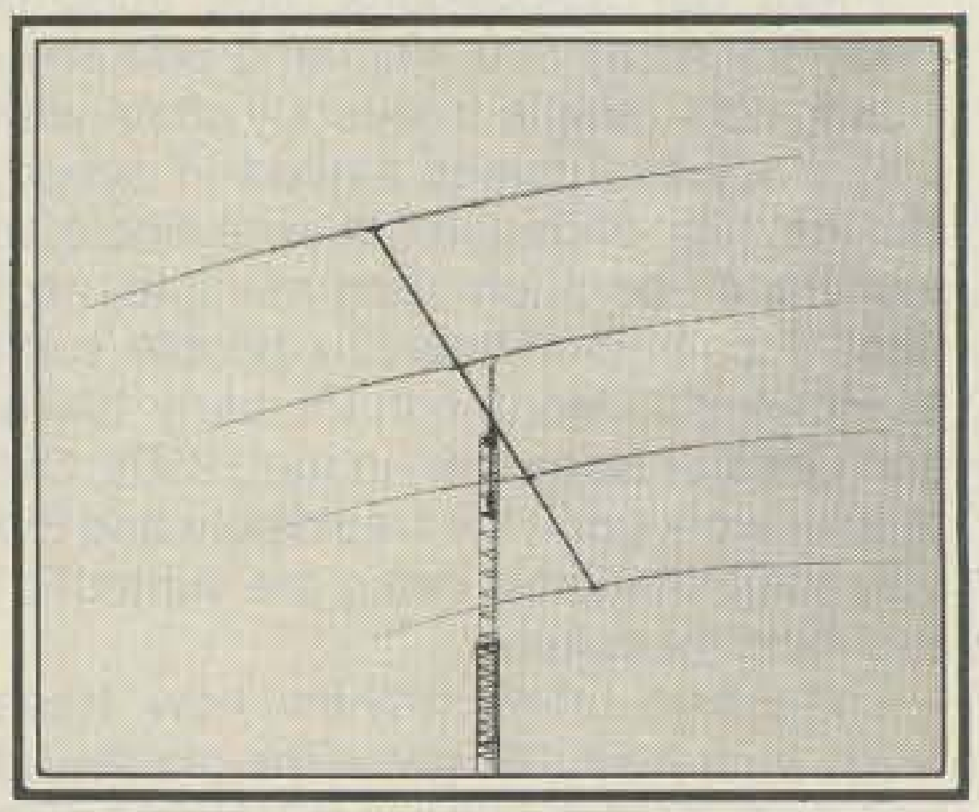
The trap dipole is normally fed with 50- to 75-ohm coaxial cable.

Fig. 1– Basic horizontal trap dipole antenna.

trap advertising literature may lead one to believe that trap feedline match is perfect over all bands that the antenna covers, but this is almost never the case in practice. Generally, it is necessary to carefully adjust the traps, shorten or lengthen sections of the antenna itself, or, as a last resort, even change transmission line lengths to get uniform transmitter loading on all bands. Even then, perfect s.w.r. is a pipe-dream.

Nevertheless, it's important to get a *reasonable* match on all the bands that you wish to use. If the feedline is of the low-loss type and if the run to the hamshack isn't too long, losses won't be excessive and the antenna will function well with s.w.r.'s of up to 4:1 or 5:1, although you may want to use an antenna coupler or transmatch to facilitate sometimes finicky solid-state transmitter loading. The compromises involved are especially noticeable in those trap dipoles which feature a *single* pair of traps for all-band use and which rely on placing the antenna in various harmonic-resonant modes for all-band coverage. With this type of trap antenna, it's virtually impossible to achieve a 1:1 s.w.r. on all bands, since adjusting one band for optimum conditions will throw out another band.

What is especially important is high, clear, and free trap antenna installation. This is even more critical than with simple, single-band dipoles, since trap resonances can easily be upset if the traps are not installed in the clear. Like other horizontal antennas, vertical radiation angle depends on the antenna height above ground. Generally, the higher the antenna, the lower the angle of radiation will be. For most practical antenna heights, maximum radiation will be at about 30–35 degrees from the horizontal. This figure assumes an antenna height of



KLM 40-meter "Big Sticker" monoband antenna allows operation on a band where few rotatable arrays are used, for obvious reasons of size and weight. The four elements are shortened by nearly 20 feet (to about 46 feet) by the use of "linear loading" techniques for a boom length of a manageable 42 feet. In this unusual design, two of the four elements are driven to achieve a broadband characteristic and a 7.2 dB gain over a reference dipole. Feedpoint impedance is 200 ohms for matching to 50-ohm coax with a 4:1 balun. Antenna weight is 85 pounds. (Photo courtesy KLM Electronics, Inc.)

one-half wavelength. If it's less, which would normally be the case on the lower h.f. bands, then the radiation angle would be higher. If more, the radiation angle would be lower.

Something rarely considered, but something we should point out, is the fact that the trap antenna may efficiently radiate all harmonics presented to it—that's its job. While most modern-day amateur transmitting gear has sufficient harmonic suppression built in, it's still a good idea to use a transmatch in the feedline even if it is not required by conditions of high s.w.r. and/or loading problems. The use of the antenna coupler may provide as much as 10 dB second harmonic suppression and help reduce the possibility of receiving an FCC citation or causing unnecessary interference.

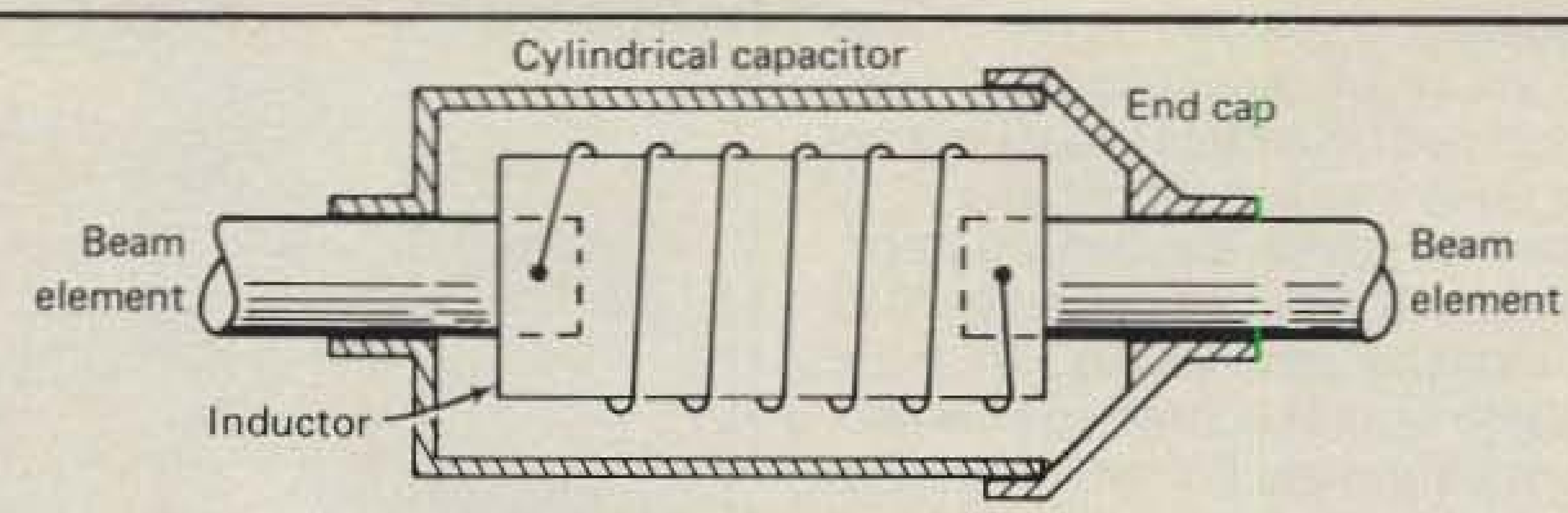
While we're now speaking mainly of the trap *dipole*, it's well known that traps can be used in other multiband antennas in the same way they are used in the basic dipole or doublet. Traps can be combined with loading coils to produce physically short multiband antennas, incorporated in vertical antennas, and—of special interest to us this month—employed in multiband parasitic arrays. Let's now consider this latter kind of specialized trap application.

Multiband Yagi

A logical extension of the trap dipole principle is the multiband trap rotatable beam, which typically takes the form of a tribander covering 20, 15, and 10 meters. The tribander uses the same trap principles as used in the dipole to resonate the driven element, reflector, and director elements of the beam to give the antenna its directionality, gain, and F/B ratio.

The trap Yagi represents an excellent compromise antenna for most operators, since it's tailor-made for those amateurs on a modest budget or who don't have the space or inclination to install multiple, full-size monobanders. While the trap Yagi won't outperform full-size Yagis designed for single-band operation, the trap Yagi can provide reasonable gain and good F/B ratio, and even some reduction in size. The only marginal situations that usually develop are those which occur when the beam is much shorter than a half-wavelength so that the traps take on the aspects of loading coils, with their attendant losses. This is normally a problem only if 40 or 80 meter operation is attempted in a multibander.

As we mentioned, the trap Yagi has its antecedents in Morgan's 1940 multiband dipole and got its real "push" from the W3DZZ 1950s articles. As in the dipole, the traps, or L/C circuits, act as frequency-sensitive switches. In the typical tribander, the inner section and traps are resonant at 15 meters, and the entire antenna is resonant at 20 meters, the story being essentially the same whether we are discussing the driven (dipole) element, the director, or the reflector.

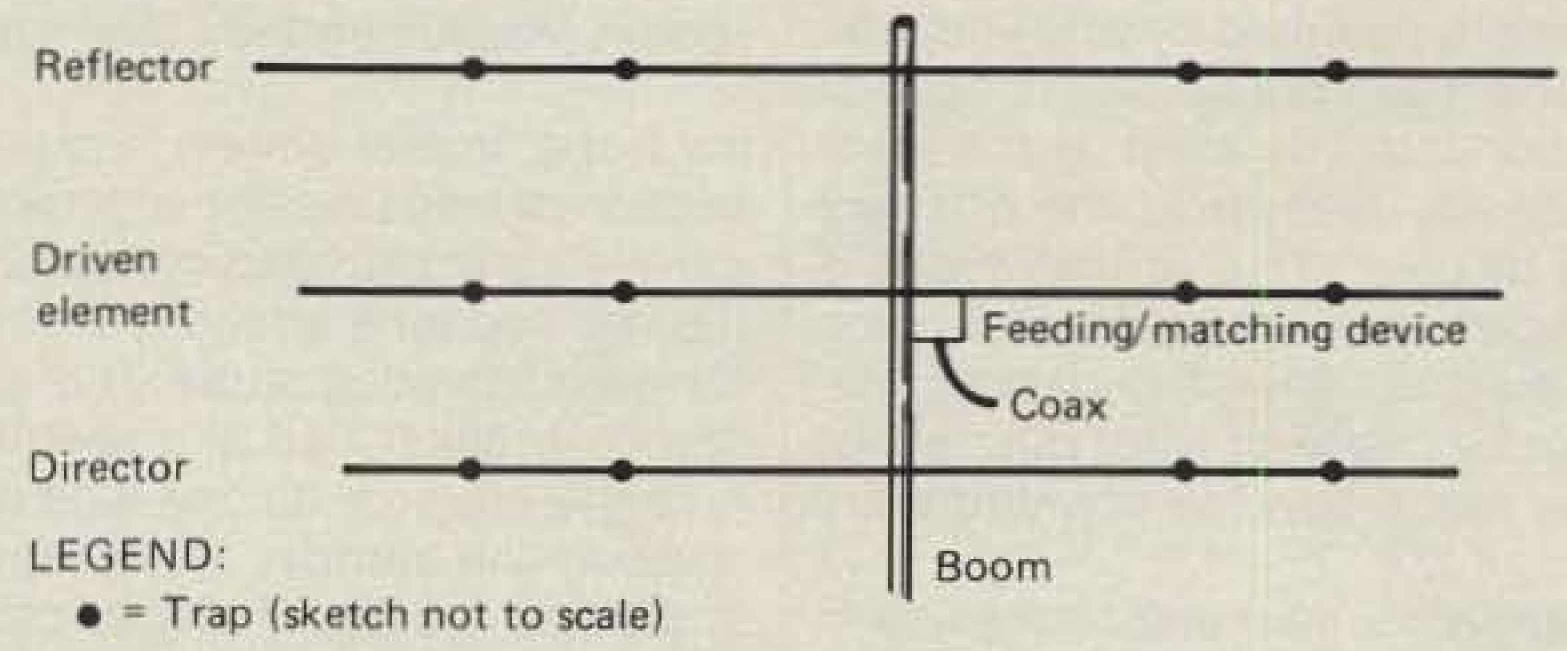


Shown above is an example of a single-band beam trap. In this design, popular with many multiband beam manufacturers, the capacitor serves as an outer shield, with air serving as the dielectric, to provide capacitance between the cylinder and the trap coil. An end-cap seals out weather, and in some designs, the entire assembly is encapsulated in a weatherproof jacket.

Electrical operation is relatively simple, but it is far more complex mechanically because of the required physical support of the antenna elements.

In some beams, two traps are combined in one housing, with two coils being contained within a single cylindrical capacitor.

Fig. 2– Representative beam trap construction.



Shown here is a partial schematic of a three-element tribander for 20, 15, and 10 meters. The driven element is split at the center for direct feed, or is left intact and fed with a Gamma match or other system. In this antenna, a total of 12 traps is required. However, some variations incorporate the two traps in a single assembly, allowing simpler design and slightly shorter element length. Also, a separate, interlaced 10-meter director is often used, allowing the main director to sport a single set of traps (for 15 meters).

Fig. 3– Representative triband trap Yagi antenna.

The heart of the multiband Yagi is, of course, the trap. A few amateurs make their own traps for multiband dipoles, using as the L/C circuit an airwound inductance and a transmitting-type ceramic capacitor housed in a waterproof housing. However, traps for triband beams are more sophisticated, having mechanical requirements that are difficult for the average amateur to fill.

Commercial multiband beam manufacturers have taken a number of approaches to physical trap design, one of the most popular being that of using the capacitor as an outer shield with air serving as the dielectric; sometimes, the trap is completely encapsulated in a tough weatherproof jacket (see fig. 2). As with the dipole, the loading effect of the traps is to slightly shorten overall element length; the result is that the multiband beam will usually be slightly smaller than a monobander for the lowest band used.

There is some loss in the tribander, but not so much as to become objectionable. But one area in which degradation is noticeable is with respect to bandwidth. Typically, on 10 meters, usually the top band, bandwidth is not noticeably different from that of a 10-meter monobander. But on 15 and 20, a portion of the element on each band is made up of the trap(s) for the higher band, tending to slightly restrict operational bandwidth. This effect is most pronounced on the lowest band, 20 meters, where boom length is often shorter than optimum, thus aggravating the problem. This is not to say that operating performance will be noticeably degraded, but s.w.r. may rise at or close to the edges of the operating band. This may cause loading problems for solid-state transmitters or transceivers, in which case an antenna coupler may be used to smooth out s.w.r. variations.

To this point, we have used the term "multiband Yagi" as being synonymous with "trap Yagi." Actually, there are oth-

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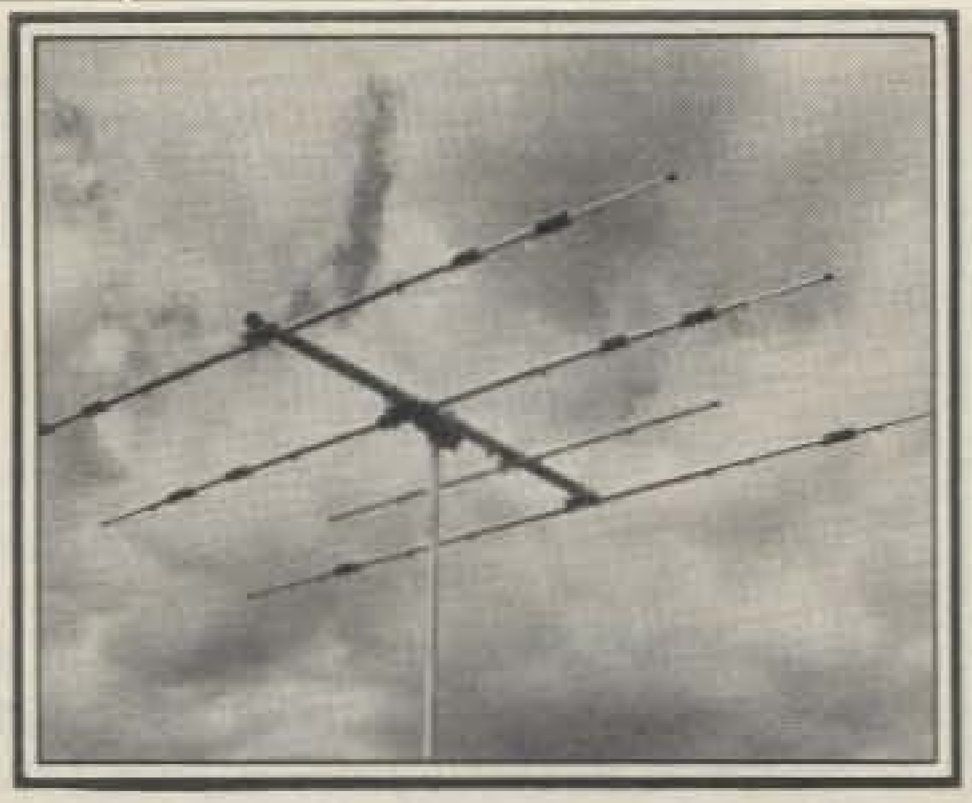
er ways to develop multiband operating characteristics in the Yagi array. These methods are much less frequently used than are lumped constants (traps), but we should at least mention them here.

Besides the familiar decoupling traps, resonant coaxial sections can be used to develop multiple resonances. In a tribander, there would be three coaxial sections used: a short section which is resonant at the highest operating frequency; a longer, center section which is resonant at the next lower operating frequency; and a long inner section which is resonant at the lowest operating frequency. The sections are decoupled from one another because the impedance between the tip of each outer section and the adjacent inner section is very high. One difficulty with this arrangement is that the high "Q" of the system makes adjustment difficult, time-consuming, and critical.

In a variation of this concept, the coaxial sections are replaced by *wire* linear elements. The result is a system of parallel dipoles connected together at the feedpoint in similar fashion to the ordinary "multiple dipole." This arrangement is much simpler and less costly that using coaxial sections, since the parallel elements can be made of wire, but neither method is much used in contemporary designs.

A system some manufacturers use in contemporary designs is linear decoupling traps. In this system, a quarter-wave section of transmission line replaces the parallel-tuned lumped-constant L/C trap; the line sections effectively act as quarter-wave isolating stubs. This system effectively makes use of a segment of the antenna element as one side of a transmission line section. The linear decoupling traps, if cut and placed properly, effectively decouple portions of the antenna from the balance of the antenna for multiband operation, thereby achieving an overall effect equivalent to that achieved by traps, probably with even lower loss.



Contemporary h.f. Yagi design is exemplified by the Cushcraft ATB-34 tribander for operation on the 10-, 15-, and 20-meter bands using low-loss fiberglass-form traps. The antenna shown here boasts a 7.5 dBd gain on all three bands and an F/B ratio of 18–22 dB, depending on band, according to manufacturer's data. Note single pair of traps on the director, with a separate interlaced 10-meter director. (Photo courtesy Cushcraft Corp.)

In addition, various *interlaced array* designs can yield multiband operation, but without the use of lumped constant, linear, or coaxial decoupling devices. This array is one in which the elements of two or more antennas are aligned in a single plane and supported by a common structure. Various combinations are possible, but individual two- or three-element monobanders separately fed (usually through a coaxial switching relay to make use of a single transmission line) on the same boom are most used.

Interaction between the interlaced elements isn't prohibitive, if the elements are properly spaced and adjusted, and wind loading is not as great as would be the case if the antennas were stacked Christmas-tree style. Still, working with interlaced arrays entails a great deal of cut and try, and often the system is plagued with spurious resonances and interlocking tuning and adjustments. Some hybrid interlaced designs, in an effort to reduce the weight of "metal in the air," have made good use of ordinary trap-type driven elements. Fig. 3 displays a representative triband trap antenna configuration.

(To Be Continued)

a monthly feature by
KARL T. THURBER, JR., W8FX

Antennas

DESIGN, CONSTRUCTION, FACT, AND EVEN SOME FICTION

The H.F. Yagi: Part III—Construction Techniques

Author W8FX set the stage for discussion of the Yagi by taking us from the basic dipole to complex, multi-element, multi-band arrays. In this article, we start with the Yagi vs. quad controversy and get into general beam construction considerations.

Up front, let me state that anything I might say regarding the superiority of one antenna over another (especially for DX work) is fraught with risk. The subject of antenna performance is a favorite topic of many amateurs, and it provides an almost unlimited source of animated, if not downright heated, discussion. So at considerable risk, I will make a few comments on DX antenna choice and performance based on my own experience and readings: first, on the merits of fixed vs. rotatable arrays, then on Yagis vs. quads.

As far as fixed arrays are concerned, the bottom line is that they are *generally* unpopular in the amateur DX community, with the possible exception of the V-beam and rhombic for specialized applications. Although some fixed arrays may offer high potential gain, it's likely that this gain is rarely attained in practice since it's unusual for such arrays to be installed at heights comparable to the heights at which rotatable Yagi and quads are normally installed. Long single wires and extended double Zepps are also popular for the amateur who does not have the resources to erect a rotatable array, although these types have limited utility since more than one antenna is required for around-the-compass coverage.

Ground planes are inexpensive and popular. Many serious DXers like to use the ground plane's omnidirectional characteristics before switching over to beams in stalking DX, finding it a definite asset to be able to transmit and receive equally well in all directions, at least initially. This feeling is at the opposite end of the spectrum from that which says that an antenna must be rotatable to be really effective.

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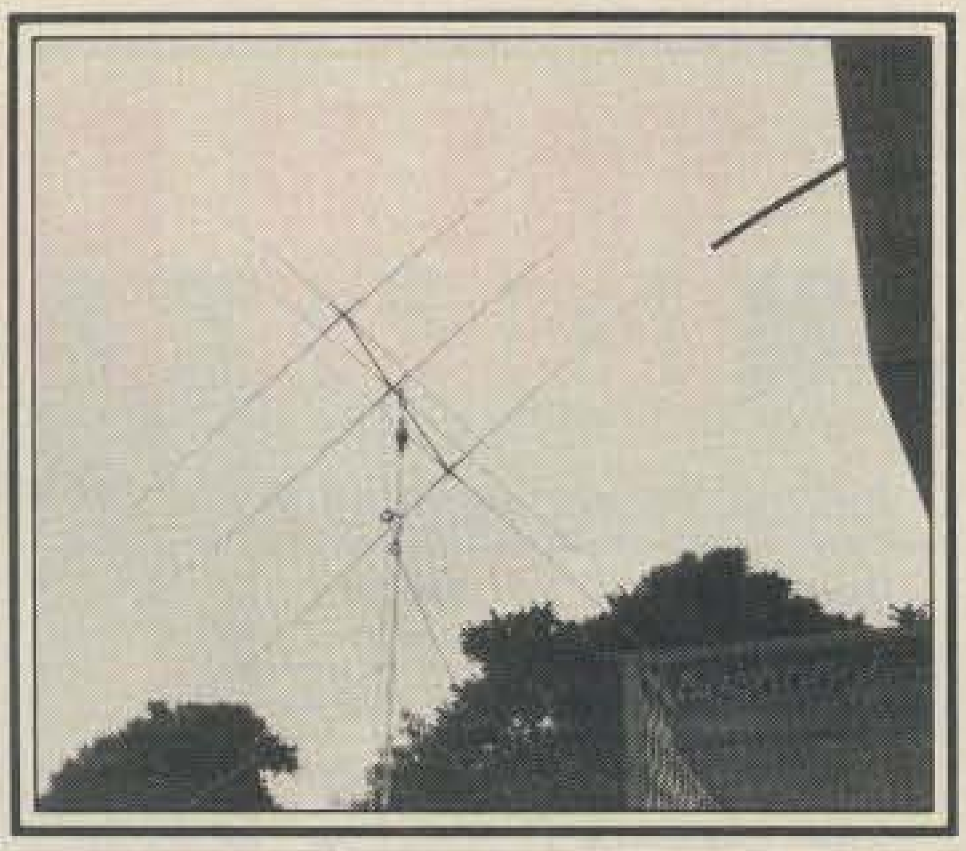


A competition that probably will never be settled amicably is that between Yagi and quad enthusiasts. Element-for-element, the quad offers more gain and generally better overall performance, but the bulkiness and wind area of the latter make installation tricky and cumbersome. The three-element h.f. quad shown here offers about a 10 dBd gain. (Photo courtesy Skylane Quads)

Both the Yagi and the quad are highly efficient antennas that can provide considerable gain not available from the simple dipole and vertical, coupled with a quantum jump in flexibility over most fixed arrays. Also, the front-to-back (F/B) and front-to-side ratios of both types of antennas considerably reduce interference from undesired directions while concentrating the transmitted signal in the desired direction.

Of the two types, the Yagi is probably the more popular (particularly in the three-element monoband version), whereas the quad is slightly better than the Yagi for DX work, on an element-for-element basis. On one hand, the Yagi is mechanically strong and features a very tight unidirectional radiation pattern for DX work; on the other, it's difficult to homebrew a trap Yagi due to the mechanical complexities of constructing and inserting the traps in the elements. The quad is relatively easily built for either single- or multiband operation, but it's a tricky antenna to handle and get up in the air.

Here are a few observations regarding comparisons between the two antennas. I've tried not to "take sides," but rather just present the facts as I have gathered them. Consider the following:

(1) All beams work best high in the air, but the quad seems to be more forgiving of height deficiency than the Yagi, and also exhibits less ground effect and ground loss. Of course, a good natural QTH can offset individual antenna deficiencies quite easily.

(2) The quad is about equivalent in power gain to a Yagi having one additional element. The quad also exhibits more gain than the Yagi does for a given boom length, weight, size, and turning radius.

(3) The quad has a slightly lower radiation angle than the Yagi. This often results in one's signals being the "first in" and "last out" when using a quad.

(4) On receiving, the quad is a relatively quiet antenna, being less vulnerable to precipitation static on reception than its Yagi counterpart.

(5) The quad is more broadbanded than the Yagi, being a low-Q closed loop. This makes the quad less critical of on-the-nose tuning. End effects, prevalent with dipole-like open elements, are much reduced.

(6) The quad is less vulnerable to lightning strikes and static discharges than is the Yagi, as it has no sharp end points.

(7) The quad is easier to adjust for proper performance than the Yagi since there is less interaction between the elements, there is less critical element spacing, and there are no traps to tune. However, feeding schemes can become quite complex in the quad.

(8) The Yagi is more aesthetically pleasing than is the quad, at least in the public mind.

(9) The Yagi is less susceptible to damage from strong winds and ice storms.

(10) The quad is less popular than the Yagi, mainly because it requires added effort to install and maintain. A "boxy" antenna, the quad is bulky and fragile to handle and hoist into the operating position when compared with the Yagi.

(11) The quad is an inherently inexpensive antenna if made of bamboo, although it can become more expensive than the Yagi if specially fabricated fiberglass spreaders, aluminum spiders, and other custom fixtures are used in construction.

All factors considered, there is very little on-the-air difference between the two

most common competing antennas—the three-element Yagi and the two-element cubical quad. The choice boils down to a personal one, and should be based at least partially on practical assembly, construction, installation, and tuneup considerations rather than narrow differences in expected performance statistics. Use of either type antenna will result in considerable DX improvement over the simple dipole or groundplane vertical, whether operated on a single- or multiple-band basis. Too, overshadowing the considerations we've mentioned, local factors such as man-made obstacles, geographical location, method of feeding, transmitter power output, and type of ground all enter the picture. In any case, the choice is clearly yours!

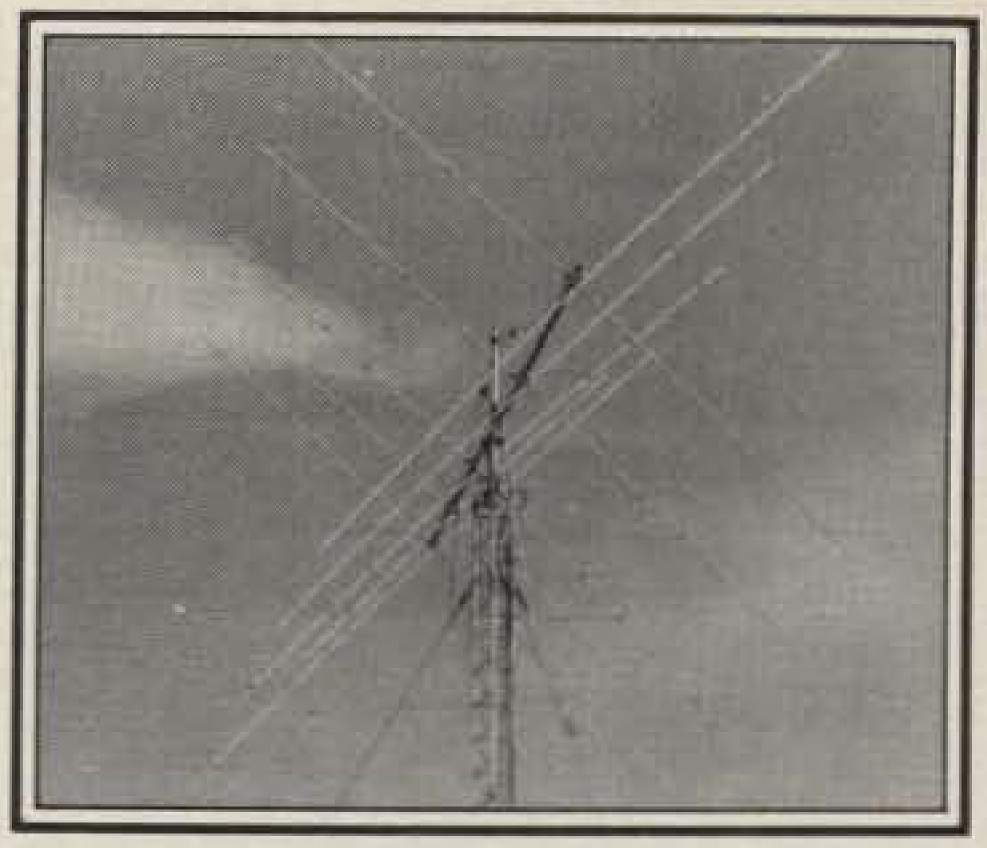
Construction and Installation

Our emphasis is on the "survey approach," so we won't go into intimate detail on construction techniques, although we will present some general beam construction guidelines you should find useful. The bibliography, found at the conclusion of this series, should prove helpful, particularly if the decision is to "roll one's own."

A basic question is, should you build or buy your beam? Antennas represent one of the last preserves of the do-it-yourself hobbyist; fairly impressive results can be achieved with a modest investment of time and dollars, and h.f. antennas are not so difficult to build that it is necessarily best to defer to a manufacturer's expertise. However, the cost of raw materials, such as aluminum tubing, has skyrocketed, and many builders have found tubing difficult to find and of limited selection. A sorry situation, perhaps, but a factual one; as a result, only the most persistent will construct their own h.f. "plumber's delight" today.

Our bibliography will lead you to some solid reference sources if it's your desire to buck the tide and scratch-build your array. Recognizing that most amateurs buy ready-made beams, our approach is to emphasize selection considerations, and to provide some tips on what follows: installation, feeding, matching, tuneup, and operation.

The rotary beam is an orchestrated collection of parts, conductors, insulators, supports, nuts, bolts, stubs, connectors, and the like. The "conductors" play a key part, and foremost among them—especially in the "plumber's delight" design—are the elements. While there are several ways to build a beam, this all-metal design is the most satisfactory. This design allows the array's center to be at ground potential for easy lightning protection. The array is weather resistant and strong; by way of comparison, insulating materials, such as wood, plastic, porcelain, or bakelite, may be broken by



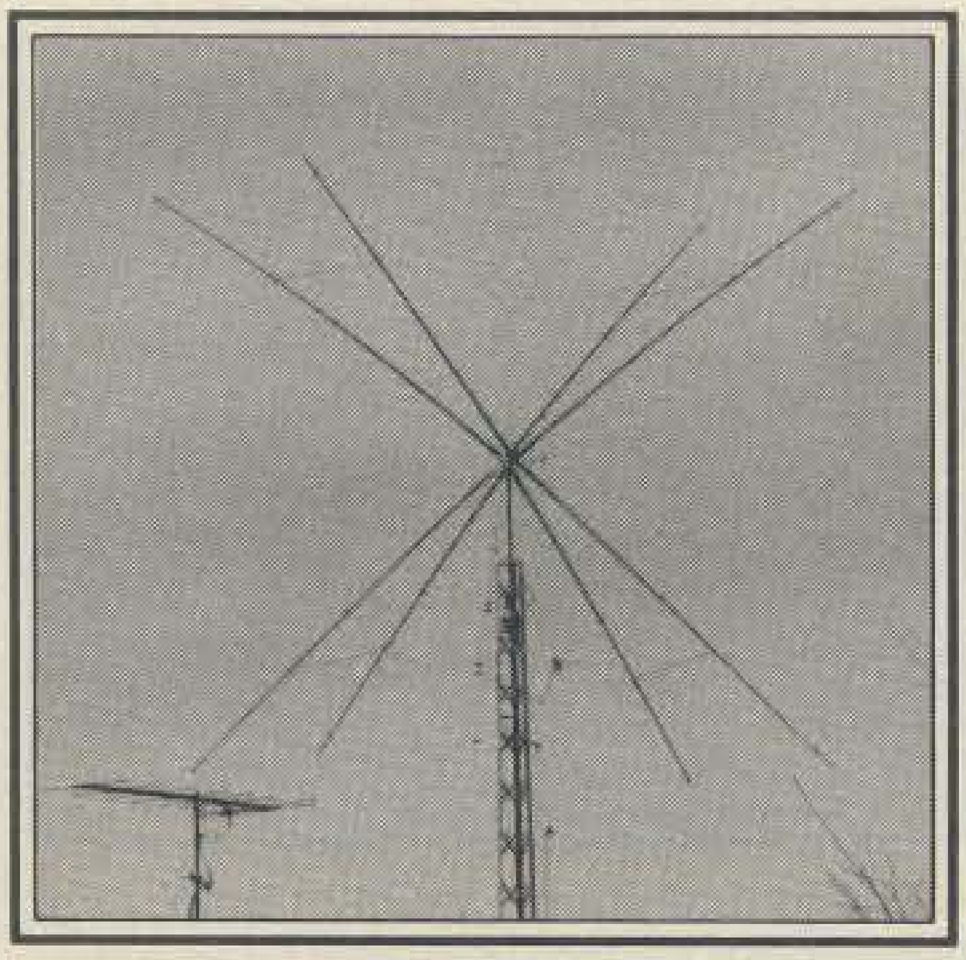
Although bulky and difficult to erect, large quads offer increasingly stiff competition to the Yagi; the quad is about equivalent in power gain to a Yagi having one additional element. Shown here is a five-element quad; such configurations offer as much as 13 dB gain over the half-wave dipole. (Photo courtesy dB + Enterprises)

wind stress or may deteriorate from continuous exposure to the weather.

Aluminum and steel tubing or pipe are generally employed for the elements and boom; usually, both are made of aluminum tubing, while the hardware is of steel (sometimes plated). Because of its strength and ease of working, 6061-T6 (61S-T6) round aluminum tubing is frequently used; it is generally sold in 12-foot lengths by the pound. The tubing generally stocked by suppliers runs from ¼" OD to 4" OD or greater, with wall thicknesses of from .049" to .125". Obviously, the inner sections and the boom should be constructed of the heavier grades.

Keep a few points in mind. The 61S grade is probably best for h.f. beam elements; softer alloys may not be suitable. The telescoping elements should be arranged so that the center section is one continuous length for high strength. Large h.f. arrays require the use of a suitably rugged boom; 2–4" diameters are frequently used, and are sometimes made of aluminum irrigation pipe. Tubing can be spliced together to form the boom, although special care must be taken to preserve mechanical integrity and electrical continuity.

It's fairly easy to evaluate an antenna from a mechanical standpoint, if one can see it up close or mounted atop a tower. Undersize or cheap construction is generally highly visible, especially when the array is in the air. It's a little less obvious when it comes to hardware. Suffice it to say that parts at load-bearing points should be rugged. Heavy hose pipe and muffler clamps, aluminum angle stock, pipehangers, cast aluminum fittings, and other hardware are commonly used for these tasks; these should "look the part" when it comes to providing visible support. A perennial problem is corrosion, which, over time, can reduce the best beam to rubble if unchecked. Any antenna hardware that is subjected to corrosion should be treated or protected. Plated nuts and bolts are a good investment, since most antenna hardware, even that found in commercially designed kits, is untreated. Several methods can be used to increase protection. These include spraying the hardware with some type of rust-preventative primer or paint, or coating surfaces with oil. An even better solution is to have all the hardware, including washers and nuts, cadmium-plated. This



The answer to the question, "which is best, quad or Yagi" is not easily forthcoming. Proponents of each design list numerous advantages. The real answer can, at best, be written in terms of "best for whom" using some of the considerations mentioned in the text. Shown here is the Canadian Gem-Quad 2-element "boomless" quad tribander.

involves taking the hardware to a job shop and having them run the parts through a plating bath. While a modest fee will be charged, the hardware will last a long, long time if so protected. Silicon sealing grease can be used to protect coaxial connectors.

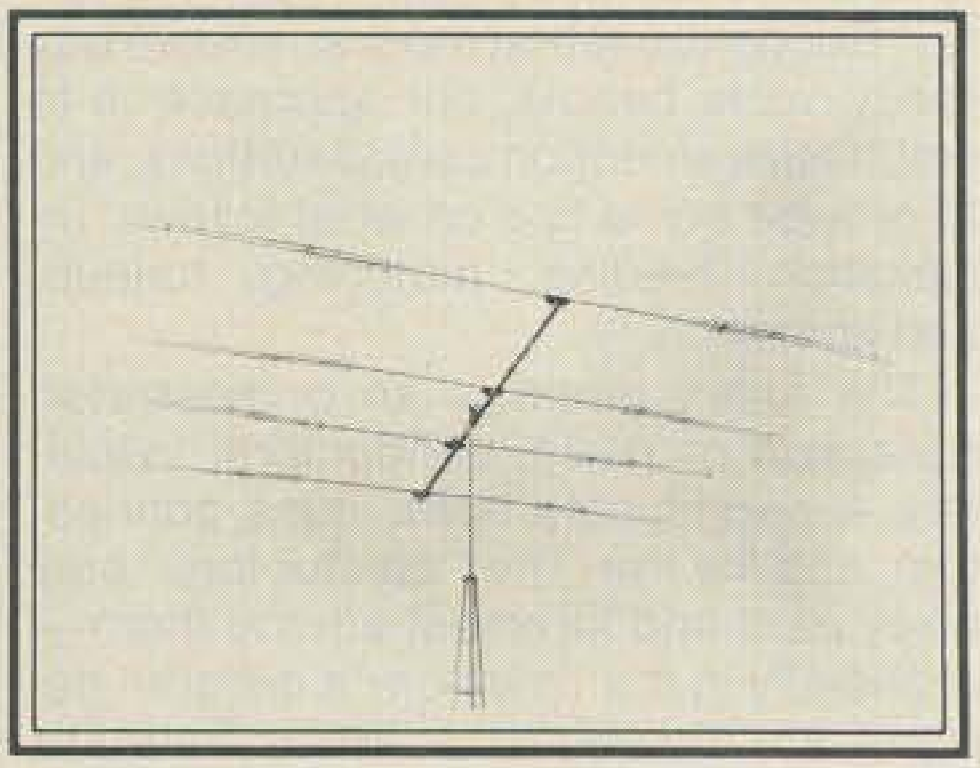
Antenna assembly can be the worst part of the whole operation; this requires patience. Assuming a commercial kit has been purchased, the first step is to open the package and place the parts in an "assembly area" that is off-limits to all but antenna party participants—both to avoid inadvertent loss of parts and to protect others from injury. The package should be carefully checked against the parts list, and some time should be devoted to reading the instructions. A little time taken at these points will be time well spent. Most well-designed kits contain concisely written instructions and most of the information needed to complete the antenna assembly. In many cases, all that is needed in the way of tools are a screwdriver and wrenches.

What about the tower? A tower or support of some type is, of course, needed to get your beam in the air. The higher the better, although most amateurs use a tower between 40 and 50 feet. Telescoping or tilt-over type towers are probably best so that the tower may be cranked down or cranked over when the need arises. This allows the tower to reduce its exposure when serious weather threatens and allows for work to be done on the tower or antenna. For strength, guys may be used, or the tower may be backed up against the house, using the structure as a support. Note that if the tower is placed against the house, it must be supported by a part of the house that can take the stress. Also, towers tend to creak and hum in even light winds; the noises may be disturbing to the household. A secure base and proper grounding are essential.

In selecting the tower, the square foot wind area of your beam (plus future additions) should be matched with the wind load the tower (and rotator) will safely take. You will find these figures expressed in square feet of wind load, usually at a wind velocity of 50 m.p.h. or more. Know the average wind velocity for your location. The cost of a tower is roughly proportional to the tower's strength, durability, and height. Aluminum is a favorite material in areas subject to high corrosion, such as from salt spray, although galvanizing or aluminum coating can reduce this problem with steel towers. Note that the tower should, if possible, be erected in a place where it would not touch electric wires should it fall.

A rotator that can handle an amateur-sized array is a "must." Practically all TV-type rotators fall far short of turning heavy 20-, 15-, and 10-meter beams, although these units can be suitable for rotating medium- and even large-sized v.h.f. and u.h.f. arrays. The rotator is usually placed in some sort of cradle or mounting assembly that will vary with each installation. The idea is to provide a rugged mount for the rotator, one that keeps the weight of the antenna off the rotator. One technique is to install the rotator 8–10 feet below the top of the tower, supporting the beam mast at the top of the tower with a thrust bearing. This will tend to keep the weight of the beam off the rotator and reduce the "bending load" on the rotator due to the wind. Rotator cables should be routed so as not to provide an easy path for lightning to enter the house.

There are dozens of ways to erect the antenna, and there is probably one best way for your particular installation. Time spent in analyzing the "lift" problem, preferably pooling the experience of several local amateurs, can yield good dividends when the time for installation of a big array comes. A little pre-planning is especially important, since chances are



Rotary beam installation really isn't completed when the antenna is erected and tuned up. Efficient, effective operation depends on proper orientation and a positive means of determining signal path headings. Several methods are described in the text. (Photo courtesy KLM Electronics)

that the antenna assembly instructions provide little or no guidance for raising and mounting the beam.

While there are many unique, specialized installation techniques, the most common makes use of a ground party, "tower man," gin pole, halyard, and pulley. The objective is to have the ground party do most of the work, and to let the tower man be free to guide the antenna into position. Using this popular technique, the array is placed in a clear area, arranged to point toward the tower. The halyard is secured to the boom. It is run through a pulley attached to the top of the gin pole about 2 feet above the top of the tower. The ground crew pulls the antenna up the tower using the halyard. As the antenna is lifted and approaches the top of the mast, the tower man guides it after the lifting rope has been untied from the front of the antenna. The antenna is pulled into a horizontal position by the ground crew, and the tower man secures the antenna to the rotator mast. These operations can be tricky, and safety is paramount. Special care must be taken not to allow anyone to stand near the base of the tower while the antenna is being raised to guard against tool-dropping casualties. And, anyone who climbs the tower must wear a safety belt—not only from a safety standpoint, but from the fact that it's near-impossible to work efficiently while hanging onto the tower with one hand.

As we have indicated, each installation is different, and as a result, no general set of instructions will exactly suit a particular installation. The key to successful installation is the step-by-step thinking-through of the process to include exactly what tools, materials, and manpower will be required at each point, *all done while the antenna is still on the ground.*

(To Be Continued)

Antenna Entrepreneur

The emphasis in our Antennas Columns is that of an instructional presentation of antenna theory and design, with most material presented on a non-technical or semi-technical plane. We also like to highlight new and unusual antennas through our "Antenna of the Month" feature. Occasionally, it's nice to give a small and unsung manufacturer a boost.

We've noticed that George Shira, WD4BUM, makes the flea market scene at many, if not most, of the hamfests in the southeast—at least, at most of those that we attend. George sells several kinds of unusual, custom-fabricated h.f. and v.h.f. mobile antennas, as well as a line of mobile mounts. He doesn't advertise, except by word-of-mouth, and he describes his operation as strictly a "mom and pop" enterprise. I finally had an eyeball QSO with this personable fellow at the Atlanta Hamfest, where he showed me an interesting line of continuously loaded fiberglass monoband mobile antennas for 80 through 10 meters; these are manufactured to his specifications by a local factory near George's QTH. According to George's tests, these whips are about equivalent in performance to standard center-loaded whips, but have much less wind resistance than the usual whip-and-coil combination. His whips are also much less expensive, running about $11 each. He has devised a unique triple mounting bracket for parallel (no band-switching) operation of three of these whips on a travel camper. George showed me some sturdy 10-, 6-, and 2-meter magnet mount antennas and a collinear for under $15.

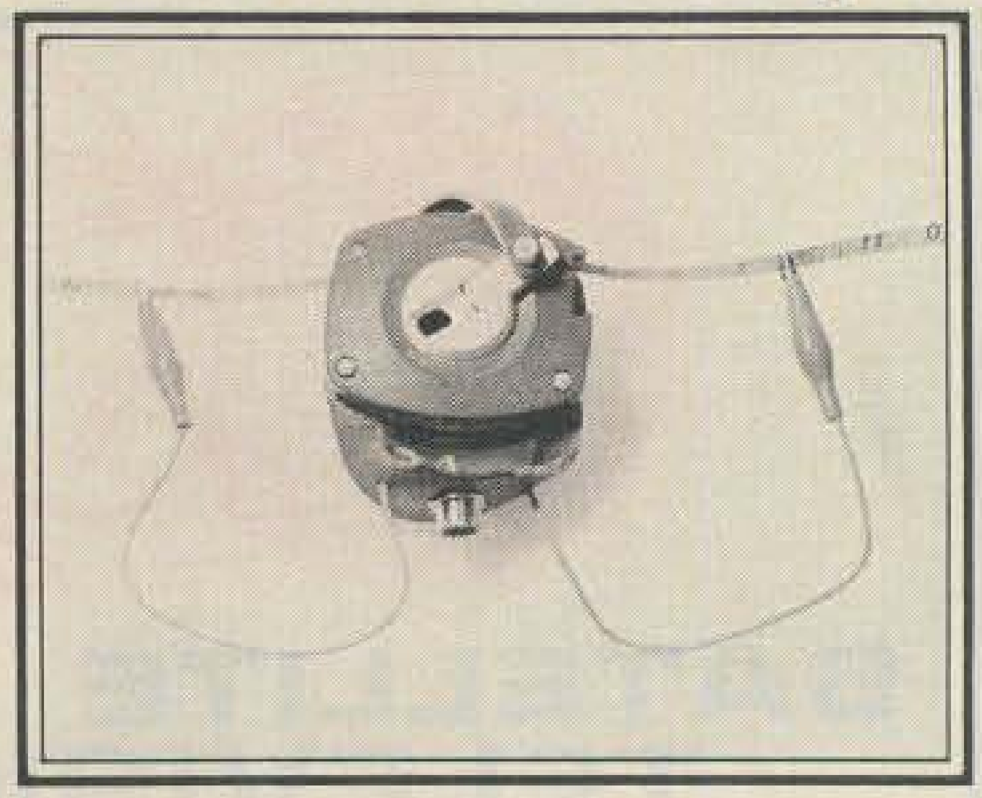
As I said, George doesn't advertise, but the modest line of inexpensive, unusual antennas and fittings deserves a plug. George's address is Rt. 7, Box 101-I, Anderson, SC 29624.

Summing Up

Next month we will take up and conclude our discussion of the Yagi antenna. We'll get into feeding, matching, and tuning the Yagi, as well as some practical tips on using a beam antenna. Finally, we will give a useful bibliography on selected readings for those of you who wish to delve deeper into Yagi-Uda arrays.

73, Karl, W8FX

Antenna Of The Month: Spencer Products "Tenna-Tape"



This interesting portable antenna manufactured by Spencer Products is intended for ham-band use from 10–40 meters, but it can be set to intermediate lengths for shortwave band monitoring.

The inexpensive antenna is made from two Stanley 50-foot steel tape measures coated with Mylar; the leather strap is attached to one handle and has a hole that fits over the other one, thus preventing the tapes from unrolling. Designed for indoor or outdoor use, traveling or camping, the tapes crank into a high-impact, compact housing for storage. The antenna can be used as a dipole, inverted-Vee, or sloper. Conceivably, the tape device could be set up as an off-center-fed Windom.

The Spencer Products "Tenna-Tape." (Photo courtesy Spencer Products, 18 Reynolds Avenue, Cortland, NY 13045)

a monthly feature by
KARL T. THURBER, JR., W8FX

Antennas

DESIGN, CONSTRUCTION, FACT, AND EVEN SOME FICTION

The H.F. Yagi: Part IV - Care and Feeding

In this concluding segment of our discussion of the h.f. Yagi antenna, W8FX delves into the three areas of major concern. These areas are feeding, matching, and tuning the Yagi antenna. Several methods are presented and discussed. A bibliography follows with suggested readings on this interesting and popular antenna.

Generally, coaxial cable is used to feed the rotary beam, in common with most other popular antennas. However, practically any of the usual methods of dipole feed can be adapted to the driven element of the beam.

In some beams, the driven element is split in the center and the two halves are fed from a balanced source. This kind of arrangement is particularly suitable if open-wire transmission line is to be used to feed the antenna, though it is usually not desirable from a mechanical standpoint, since it means that the element halves must be insulated from the supporting structure. This complicates and weakens the structure.

A folded dipole is sometimes used as the driven element, in which case a balanced transmission line may be directly attached to the element. A two-wire folded dipole can provide a good match to 300 ohm line, while a three-wire folded dipole can result in a good match to 600 ohm line. Alternately, an impedance matching network may be used to couple the high impedance transmission line to the very low impedance termination offered by a single-wire dipole driven element.

Another approach to feeding the split dipole driven element is by means of a linear matching transformer, known as a **Q-section.** This is an electrical quarter wavelength of transmission line having a characteristic impedance that is the geometric mean between the two impedances to be matched. If a low impedance load (the antenna) is placed across one end of the quarter-wave line, it will be transformed into a high impedance across the transmission line. The Q-secton can be configured to work with either coaxial or balanced transmission lines.

*317 Poplar Drive, Millbrook, AL 36054

The balun is one of the more commonly used devices to achieve effective power transfer from the transmission line to the antenna. The device, coming from the term "balanced-to-unbalanced" converts from the unbalanced coax to a balanced output by transformer action. The Palomar 1:1 ratio balun shown here matches 50 or 75 ohm coax to 50 or 75 ohm balanced loads. The 4:1 ratio version matches 50 or 75 ohm coax to 200–300 ohm balanced loads. An adjustable U-bolt provides for convenient mounting to mast or boom; teflon insulated leads connect to the beam's driven element. (Photo courtesy Palomar Engineers)

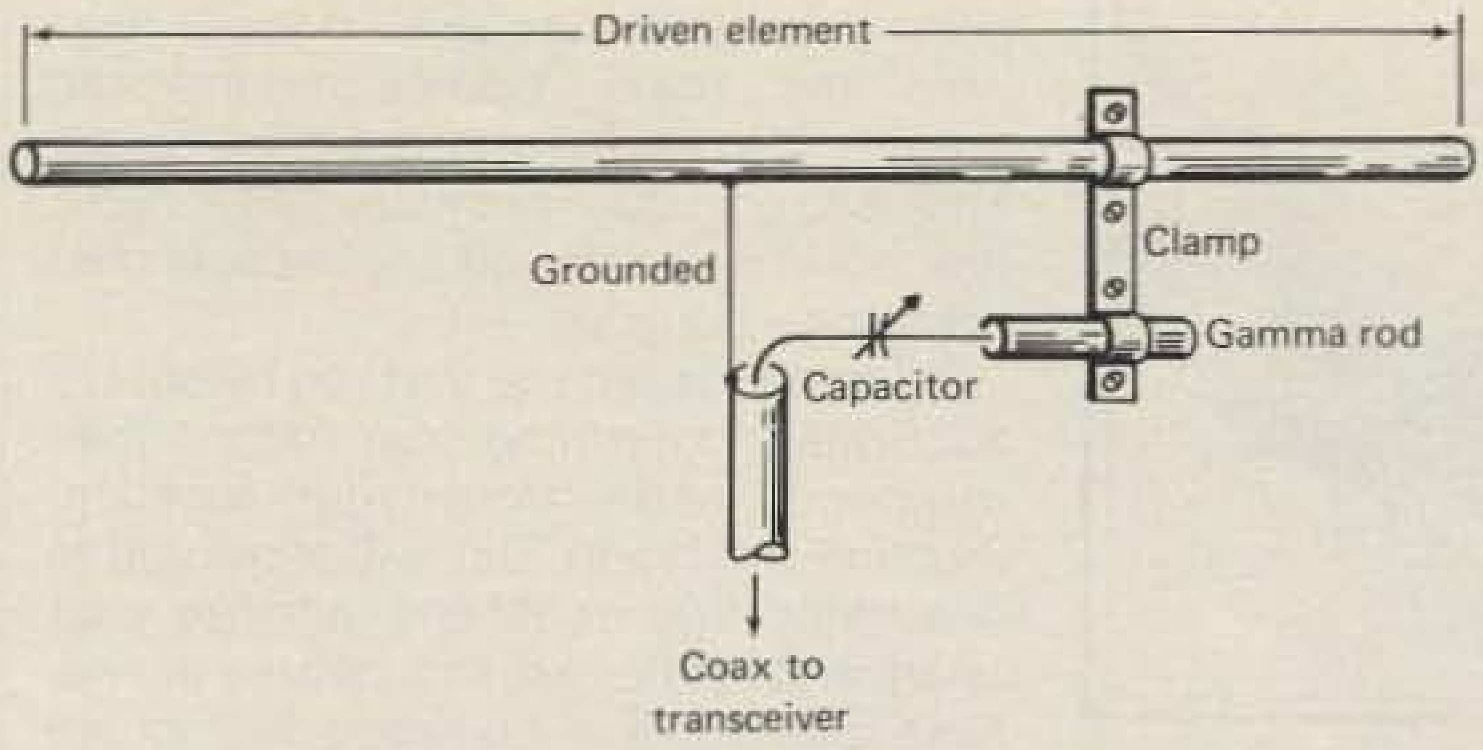
Baluns or **bazookas** are also popular devices used to feed the split driven element. The *balun* is a device that matches an unbalanced coaxial transmission line to a balanced load, such as a dipole or a Yagi driven element. The balun can become very important to the successful feeding of the Yagi, since it can help equalize r.f. flow and prevent antenna current from flowing down the outside of the coaxial cable, which could unacceptably distort the radiation pattern of the antenna. Baluns can be 1:1 devices offering no impedance transformation, or they can be transformers in the sense that they transform impedance, usually in a 4:1 ratio.

Several different types of baluns and bazookas are available. The classic coaxial *bazooka* is simply a shield placed around the feedpoint end of the coaxial transmission line, which is connected to the outer side of the line a quarter wavelength back from the line's end. The quarter wave detuning sleeve isolates the end of the outer conductor of the unbalanced coaxial line, thus permitting direct connection to a balanced antenna. Another type, the balanced bazooka, is similar in construction but uses a quarter-wavelength piece of coaxial cable rather than a sleeve. Both types provide 1:1 impedance match. A half-wave section of line, folded back on itself, can be made to act as a phase inverter to provide a 4:1 impedance match. This kind of balun would be used when it was desired to feed a folded dipole driven element with coaxial cable.

Increasingly common is the **broadband balun,** constructed either of coils or of a ferrite material, to effectively cover several frequency octaves. This kind of balun is especially useful in directly feeding the multiband Yagi having a split driven element. Inexpensive, low-loss beam baluns are readily available from a number of manufacturers.

The more popular, and mechanically superior, methods of feeding the Yagi array are based on leaving the driven element in one piece and shunt-feeding it with either balanced or unbalanced transmission lines. The oldest type of shunt-feed matching device normally used with parasitic arrays is the **delta-match**, in which the driven element is fed with a 300–600 ohm transmission line which is fanned or tapered-out as it approaches the driven element. This system allows a fair impedance match, but adjustment interacts with the driven element's tuning, making it inconvenient in practice.

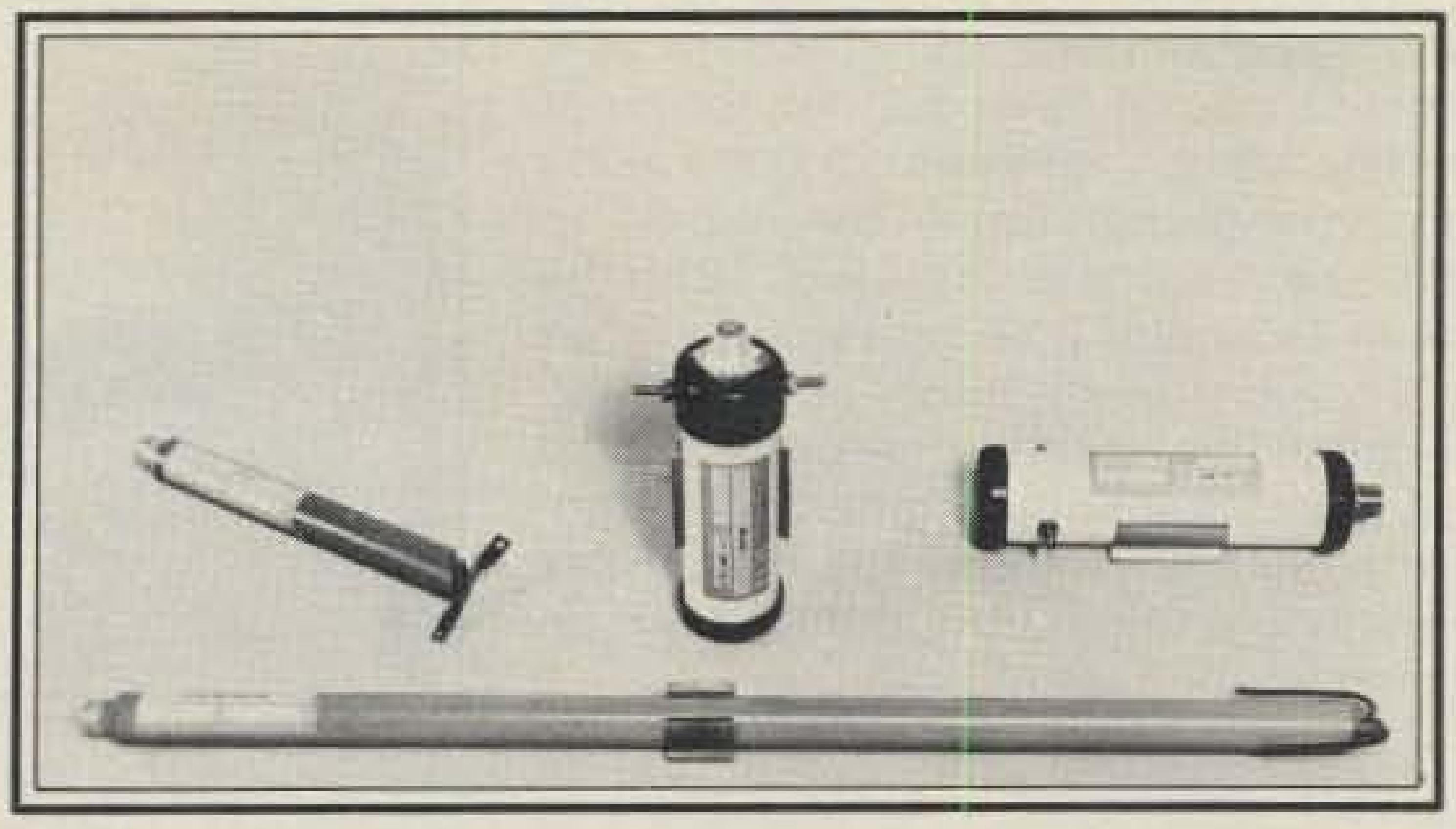
A refinement of the delta-match is the **T-match**, a much easier to adjust adaptation. In the T-match, which resembles the *gamma-match*, there are two T-rods



Illustrated here is a typical gamma-matching system, in which the coaxial transmission line is connected to the beam by means of a series capacitor and gamma rod. The gamma rod's diameter is small with respect to the diameter of the dipole element; the far end of the rod is shorted to the driven element by means of a moveable clamp.

In adjusting the system, the length of the gamma rod is adjusted along with the setting of the capacitor until the lowest possible s.w.r. is attained.

Fig. 1– The gamma match. Actually one-half of the older T-match, the gamma-match is probably the most popular Yagi beam matching device in use today. The device allows the driven element to be one strong unbroken length, and permits easy matching to coaxial cables.



When using balanced antennas with standard, unbalanced coax lines, it's wise to include a balun for optimum performance and to avoid antenna pattern distortion, particularly with beam antennas. Shown here are representative KLM ferrite-core baluns for h.f. use, and very low-loss sleeve types for operation on 2 meters and higher frequencies. The firm also sells a line of similar-appearing v.h.f./u.h.f. power divider/couplers for those who wish to stack beams for EME, DX, tropo, and satellite operation. These couplers or power dividers replace the usual "rat's nest" of matching cables and connectors required for beam stacking; they can be configured to handle from 2 to 32 antenna stacks. (Photo courtesy KLM Electronics, Inc.)

spaced a short distance from the driven element by means of adjustable straps; resonating capacitors are incorporated in each leg of the T-match for adjustment purposes. A further modification of the T-match combines the basic T-match with a balun transformer to match the unbalanced coaxial transmission line to a balanced split dipole driven element.

This brings us to the most popular beam matching device, the **gamma-match** (fig. 1). This device is really half of a T-match, and is used to match unbalanced coaxial line to either a balanced or unbalanced driven element. The device consists of a single "gamma rod" and a series resonating capacitor; the resonating capacitor acts to cancel out the detuning effect of the rod. Use of the gamma-match allows the outer shield of the coax to be grounded to the center of the driven element, which is good from a safety standpoint. For many reasons, the gamma-match is probably the best device to use when feeding the Yagi with coax.

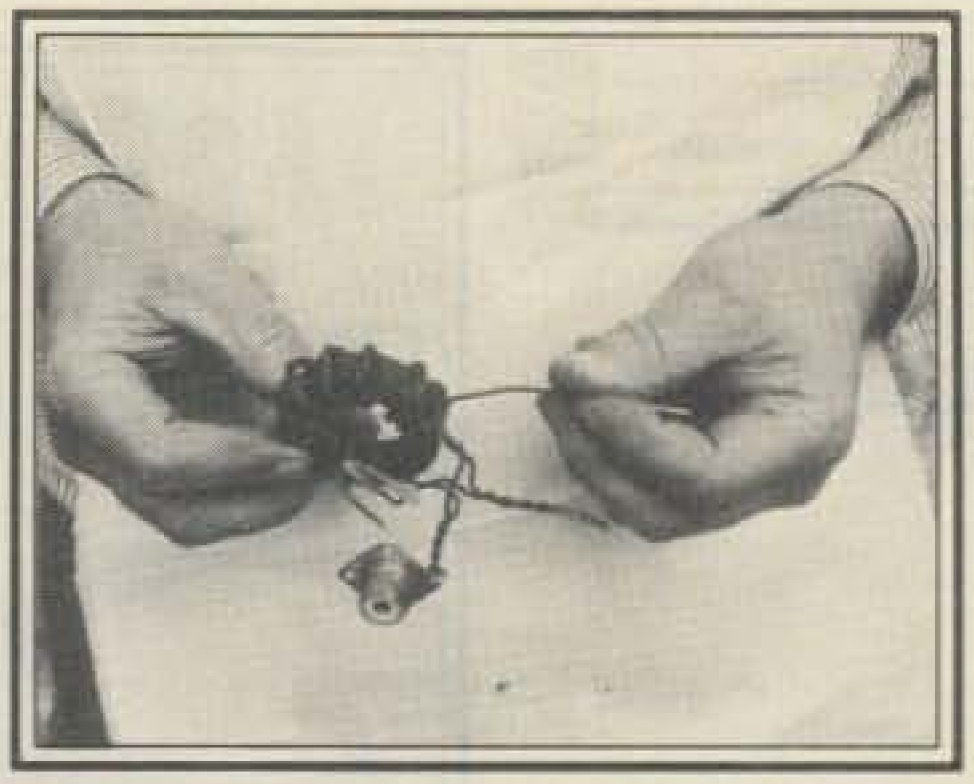
There are several versions of the gamma-match. In one version, known as the **coaxial gamma-match**, the resonating capacitor forms a portion of the gamma rod. In this case, the gamma rod is made of concentric sections of aluminum tubing; the capacitance is changed by varying the position of the outer aluminum tube. The so-called **tri-gamma-match**, or **triple gamma-match**, is really three gamma-matching units connected in parallel to feed a tri-band beam with a common transmission line. Each of the three gamma-matching devices is "cut" to the proper dimensions for the band it is to cover. In practice the lowest band is adjusted for minimum s.w.r. first, then the middle band, and then the highest band. Another refinement is the **omega-match**. In this device, the matching rod is made shorter than in the usual gamma match. Instead of making the impedance ratio adjustment by varying the length of the rod, this is done by varying the capacity-to-ground at the rod's terminating end. A second capacitor, in addition to the resonating capacitor, is required in the omega-match. Some amateurs find the omega-match more practical than the gamma match on large, low-band arrays, since the capacitor adjustments are close to the feedpoint, and adjusting the capacitors is more convenient than working with the shorting bar at the outer end of the gamma rod.

Tuneup and adjustment don't have to be a great deal more complicated or time-consuming than that involved with dipoles or verticals, particularly if the beam is a factory-made model for which dimensions and adjustments are "canned." In any case, the most important aspect of antenna tuneup is to ensure that the driven element is properly set. If set incorrectly, proper adjustment of the entire system will be difficult or impossible to achieve, and performance may be degraded. Resonant frequency can be set using only the "book" dimension, though a grid-dip-oscillator or antenna-noise-bridge can be put to good use to set resonance. Preliminary measurement and adjustment can usually be done with the beam lying on the ground, with the reflector resting on the ground and the director pointed skyward. The adjustment for the driven element should hold true in the air, and it's usually not necessary to specifically tune the reflector or directors. The matching system can be tweaked for a 1:1 s.w.r. between the feedline and driven element when the antenna is raised to its operating height. Multiband trap beam tuneup is more complicated, since the individual sections of the driven element "between traps" must be adjusted for best s.w.r., and adjustments between the various bands can interact.

We've indicated that it's not usually necessary to fine-tune anything but the driven element in most beams. However, in the case of wire element Yagis, or quads, the reflectors and directors should be tuned, preferably with the antenna installed at its ultimate operating position, since the fact that the antenna is constructed of wire makes it impossible to cut and install the wire elements to the exact dimensions required. If one wishes to precisely tune the beam, it is best done on a short temporary tower using a field-strength meter (FSM) or the S-meter of a receiver attached to a simple dipole antenna located several wavelengths from the beam under test. The beam can be tuned for maximum gain by carefully noting FSM or S-meter readings as the element lengths are changed.

As for array bandwidth, most close-spaced arrays show optimum performance only over a range of 1–2% of the design frequency, or up to about 500 kHz on 10 meters. One can "fudge" a bit, getting the antenna to work reasonably well over a wider range by specifically adjusting the director or directors to yield maximum gain at the highest frequency to be covered, and by adjusting the reflector to produce optimum gain at the lowest frequency. This procedure flattens the gain curve, resulting in some gain loss at all frequencies, but allowing a more uniform gain across a broad range.

Transmission line length has no *real* bearing on antenna tuning, though as a practical matter, changing the length of the line will change the impedance at the input (transmitter) end of the line. So, in some cases, where "all is well" with the beam except for a troublesome s.w.r. on one or more bands, it may be wise to experiment by inserting short (1/10 to 1/8-wavelength) line segments to effectively change the load the transmitter sees by changing the apparent s.w.r. on the line.



Homemade toroidal balun shown here offers a good match between an unbalanced coaxial transmission line and a balanced antenna. This unit is designed for a 1:1 impedance ratio, though 4:1 units are readily made or purchased.

On The Air

Now that the array has been installed and tuned up, what next? Effective beam employment may seem self-evident, but a few things should be kept in mind.

A beam isn't much good unless it's aimed properly. While h.f. beam accuracy doesn't need to be measured to the degree, an error of more than 10 degrees is too much. Key to proper beam alignment is an understanding of the great circle bearing. The angle that the great-circle (shortest) path forms with a line running due north through your QTH is called the **great circle bearing.** This is the bearing to which your antenna should be set for maximum signal strength over a given circuit. In some cases, the **long path** may be desired, in which case the antenna should be set to the reciprocal bearing, which is 180 degrees opposite from the outward bearing.

There are a variety of DX-antenna pointing methods in use; each has its advantages and disadvantages. Probably the most common method makes use of an azimuthal equidistant map; this kind of map is made especially for use in determining radio bearings. It's possible to purchase maps that show as the center a point at or near your station location. Using the scale of great-circle bearings printed on the map perimeter and drawing a line from the center through the location of the distant station, the desired great-circle bearing can be directly read from the scale. Computer-generated great-circle bearing charts are also available, and are usually constructed for your precise location. These are becoming increasingly popular.

All methods require that you be able to accurately determine *true* (rather than *magnetic*) north from your location. Sighting the North Star will allow you to determine *true* north and initialize your beam and rotator within a degree or two. Note that while a compass will locate *magnetic* north, you must allow for the proper amount of magnetic variation for your area.

Note that at times, the shortest path between two DX stations may not be the best way to aim your antenna. In such cases, long-path provides the best results, in which case the beam should be rotated 180 degrees. This is called the reciprocal bearing, as mentioned earlier.

A final point: in evaluating the practical performance of your beam, give it a chance to perform over a period of time. Be particularly careful of comparison signal reports with both nearby and distant amateurs. Put the antenna through its paces over a few weeks or months, under varying propagation conditions, different times of day, etc.

An Interesting Product

A low-cost product that should be of interest to the antenna buff—a fairly new one—is *Coax-Seal®*, a handmoldable plastic material that is used to seal otherwise leaky coaxial fittings from moisture and corrosion. This unusual material, manufactured by Universal Electronics, Inc., 1280 Aida Drive, Reynoldsburg, OH 43068, is a permanently pliable, rubber-based plastic. The inexpensive material stays flexible in any reasonable temperature from −30 degrees F to +180 degrees F, and it adheres to all surfaces, including the new polyvinyl coaxial cable sheaths to which silicon rubber based sealers will not adhere well.

The non-conductive, non-contaminating material is sure to save a great deal of grief in protecting coaxial fittings and other beam parts high atop a tower. For amateur use, the material comes in 60" × ½" rolls for overlap taping in the fashion of ordinary taping of electrical connections using plastic electrical tape. According to the manufacturer, the material has been demonstrated in the field to have a minimum of 5 years serviceability.

In the lab the non-toxic product has been shown to resist the sun's ultraviolet rays for at least 8 years. Burial is effective for at least 5–6 years.

I've used the material, and about the only complaint I have about it is that it's strange to touch—something on the order of a child's modeling clay—sort of "goopy," as the XYL might put it. But that

characteristic seems a small price to pay for the job the material is capable of performing.

Summing Up

This wraps up our multiple-part discussion of the Yagi-Uda array. Over the course of several months, we have covered the basic dipole; parasitic element operation; two-, three-, and multiple-element arrays; the trap multiband Yagi; beam construction and installation; and feeding, matching, and tuning considerations. We have also highlighted beam operating techniques as well as some surely controversial "which is best" antenna pointers.

Is the Yagi *your* choice for an effective h.f. antenna? We'll never resolve whether it's *the* best choice for DX, since that decision depends, in the final analysis, on what *you* want in an antenna. For many thousands, however, the Yagi represents a virtually unbeatable antenna.

Next month, we will continue with another antenna subject of timely interest. See you then.

73, Karl, W8FX

Bibliography

The following sources should provide good reading, an extended technical discussion, and construction details for those who wish to pursue further the subject of Yagi-Uda arrays:

Althouse, Jack, K6NY. "Antenna Tuning with a Noise Bridge," *Ham Radio Horizons*, November 1978.

Bartlett, Jim, K1TX and Stan Gibilisco, W1GV. "The 3-Element 10-Meter Cheapie," *QST*, March 1979.

Boyer, Joseph M., W6UYH. "The Multiband Trap Antenna, *CQ*, February-May 1977.

Buchanan, Chester L., W3DZZ. "The Multimatch Antenna System," *QST*, March, 1955.

Fish, Jim, W1HR. "Let's Talk About HF Antennas," *Ham Radio Horizons*, June 1979.

Hoff, Irvin, W6FFC. "Beam Antenna Headings," *Ham Radio*, April 1972.

Koerner, Margaret, KØIQ. "The Aerial Performers of the Radio Circuits, *QST*, November-December 1978.

Johnston, William D., N5KR. "DX Antenna Pointing," *Ham Radio Horizons*, August 1978.

Lawson, James L., W2PV. "Antenna Gain and Directivity Over Ground," *Ham Radio*, August 1979.

Lindsay, J.E., Jr., WØHTH. "Quads and Yagis," *QST*, May 1968.

Lawson, James, W2PV. "Yagi Antenna Design," *Ham Radio*, May 1980.

McMullen, Tom, W1SL. "Beam Antenna Hints & Hardware," *Ham Radio Horizons*, June 1979.

Orr, William S., W6SAI. "Ham Radio Techniques" column, in *Ham Radio*, January 1981.

Orr, William S., W6SAI. "Ham Radio Techniques" column, in *Ham Radio Horizons*, December 1980.

Phillabaum, Steve, K7NR. "Installation Techniques for Medium and Large Yagis," *QST*, June 1979.

Roberts, Walter, W3CHO. "The Compact Uni-directional Array," *Radio*, January 1938.

Ross, Donald G., Jr., W2JMZ. "How DX Kings Rate Antennas," *QST*, January 1964, p. 75.

Schauers, Charles J., W6QLV, "Ham Clinic" column, in *CQ*, December 1958.

Slepian, Michael, WB2LKO. "Towering Aspirations," *Ham Radio*, February 1980.

The Radio Amateur's Handbook, American Radio Relay League, 1981 edition.

The ARRL Antenna Book, American Radio Relay League, 1974 edition.

Thurber, Karl T., Jr., W8FX. "The Dependable, Ubiquitous Dipole," in two parts, Antennas Column, *CQ*, July and August 1980.

Thurber, Karl T., Jr., W8FX. "The Trap Dipole," in two parts, Antennas Column, *CQ*, February and March 1981.

Thurber, Karl T., Jr., W8FX. "All About Traps and Trap Antennas," *Ham Radio Horizons*, August 1979.

Wilson, Alf, W6NIF. "Trap Yagi Antennas," *Ham Radio Horizons*, June 1980.